Falmouth, MA Rotational Aquaculture Plan, including:
Executive Summary
Literature Review
Habitat and Resource Assessment
Engineering and Planning for Proposed License Sites
Other Elements (including municipal roles and economic benefits)

August 3, 2017

Executive Summary

Falmouth is a special place. Over the past 50 years, development has compromised estuarine water quality and led to significant loss of invaluable marine habitat. These salt ponds, estuaries and harbors are the critical nurseries and rookeries for shellfish and finfish as well as birds and mammals that form the basis of a complex food web. Estuarine habitats also the home to harvestable species of both commercial and recreational value. Within our lifetime, we can start to return Falmouth's estuaries to the vibrant ecosystem that brought us here to work and play in the first place. Shellfish propagation is a key component of this restoration effort.

The Falmouth Rotational Aquaculture Plan has several goals, including:

- Develop a plan for the town's estuarine resources which benefits all users these area, both economically and environmentally
- Balance the harvest goals of commercial, recreational, senior, and family diggers with aquaculture growers
- Strive to balance the need and distribution of benefits associated with aquaculture development locally
- Explore and develop innovative approaches to municipal planning and propagation
- Provide an estimate of the economic and social benefits of local aquaculture to help provide a rationale for town expenditures
- Provide guidance on helping to meet regulatory water quality goals using private aquaculture and municipal propagation

Shellfish aquaculture operates within a public resource with multiple user groups. The purpose of this plan is to both define specific locations that are potentially suitable for private shellfish aquaculture and to present an approach for managing these aquaculture sites in a way that does not negatively impact other stakeholders. A Shellfish Working Group was formed to provide input to this plan and includes representatives of Town departments such as Marine and Environmental Services and Conservation Commission, Town committees, growers, neighbors and other user groups. Through this interactive, stakeholder-driven process, a preliminary set of sites that are potentially suitable for shellfish aquaculture has been identified. In addition, this plan includes an implementation strategy for these aquaculture sites based on the concept of Rotational Aquaculture License Sites (RALS) and concurrent municipal propagation of commercially important species such as quahogs. The overall nitrogen-removal of this program has also been quantified.

This plan includes the following Sections:

Section 1: Literature Review:

This section presents the results of the literature review of aquaculture plans from other areas and was used to determine the sections contained in this plan.

Section 2: Resource Assessments and Potential Aquaculture Development Areas

Section 2 presents the results of resource assessments derived from the following sources:

- Division of Marine Fisheries (DMF) Shellfish Suitability Areas
- DMF Designated Shellfish Growing Area Maps
- MA Department of Environmental Protection (MA DEP) Eelgrass Maps
- Shellfish Habitat Assessment Maps for West Falmouth Harbor, Childs/Eel River and Green Pond
- Draft Green Pond Harbor Management Plan (July 2009)
- Massachusetts Estuaries Project Reports (dates vary)
- GIS maps of boat landings, yacht clubs, moorings and other public use areas

From these information sources, existing conditions have been summarized on a series of maps, and potential areas for aquaculture have been identified. Using a customized decision support tool, the Falmouth Shellfish Working Group and other stakeholders reviewed these potential aquaculture sites. Section 2 also details the approach used to evaluate these sites and the results of this process.

Section 3: Description of multi-user and Rotational Aquaculture License Site (RALS) model for potential aquaculture sites

This section presents a RALS model for aquaculture license sites that links areas for private oyster farming with enhanced municipal quahog propagation. Other species such as quahogs and scallops can also be proposed for farming within these license sites. Area requirements, permitting steps and other features of this program are included.

Section 4: Planning estimates for the potential for nitrogen-removal of the Rotational Aquaculture Plan

This section estimates the number of both oysters and quahogs that can be grown using the RALS model described in Section 3, as an example. Other commercially-important species may also be grown. Based on the preliminary areas that have been identified in this plan for aquaculture and municipal quahog propagation, planning-level estimates for the nitrogen-removal that these shellfish quantities represent are presented.

Section 5: Other Issues

Several planning considerations are discussed in Section 5:

- Infrastructure needs and mooring consolidation
- Role of municipal propagation
- Economic and other benefits

Section 6: Next Steps

Several public meetings were held to review this plan. A fact sheet was prepared for distribution at these public meetings to summarize the objectives and regulatory context of this plan (Appendix A). ADA areas were adjusted based on comments made at these meetings and the maps in Section 2 reflect this input. Section 6 summarizes the questions that were raised that relate to the implementation phase of this plan.

Key aspects of the Falmouth Rotational Aquaculture Plan include:

- The town is trying to expand aquaculture AND increase municipal propagation for wild harvest AND address aesthetic concerns of neighbors AND meet regulatory requirements AND remove nitrogen in a quantifiable way for TMDL-compliance AND address the costs of implementing this plan.
- Expanding private aquaculture into estuaries using the rotational system makes sense for everybody. Growers benefit by having ideal growing locations; the local economy benefits from creation of new businesses and jobs; local restaurants benefit from the increased supply of local shellfish; commercial harvesters benefit by an enhanced wild resource; taxpayers benefit by a reduced cost of infrastructure to remove nitrogen from the water; and all residents, taxpayers and businesses benefit from the removal of microalgae to help clean up these impaired waterbodies. We believe these benefits can be attained without an undue burden to neighbors and other users of the waterways because placement of aquaculture areas has been carefully planned and moves annually so that no one area on the water is permanently affected.
- Without a rotational system, private aquaculture would only be allowed to expand in much less desirable offshore locations because:
  - Nine of fifteen estuaries in Falmouth are conditionally approved for shellfishing, and have historically enjoyed productive bottom for wild harvesting -- traditional, private aquaculture is prohibited in these locations. The rotational system we are proposing addresses this issue from a regulatory perspective and thus opens these areas for private aquaculture; and
  - Of Falmouth's fifteen estuaries, two are open for shellfishing and have historically had productive bottom. Private aquaculture cannot be located in areas with productive bottom. There are possibly one or two small sections of these estuaries are not productive areas, significantly limiting the potential for private aquaculture here. The rotational system accomplishes the goal of allowing private aquaculture to expand into these two open estuaries in Falmouth.
- The rotational system requires an operations manager to serve as a liaison with neighbors, to ensure transitions are managed and permit conditions are enforced. Someone from the Town needs to be both in the field and available to assist administratively for this level of commercial activity within our coastal ponds. This manager will also need to ensure the biomass of shellfish for nitrogen-removal is quantified and the quahogs are planted, maintained and harvested at appropriate times. This is a full-time job that is a direct result of expanding aquaculture in town.

The Falmouth Rotational Aquaculture Plan seeks to benefit all users of the town's estuaries, both economically and environmentally and balance the harvest goals of commercial, recreational, senior, and family diggers with aquaculture growers and town water quality goals.

Section 1: Literature Review

The purpose of the literature review is to ensure that the Falmouth Rotational Aquaculture Plan includes a comprehensive list of topics and methods. Plans from both coastal communities in Massachusetts as well as plans from other states were evaluated. Literature search was performed by:

- Conducting an internet search for “aquaculture shellfish plan”, plus name of 15 towns on Cape Cod separately
- Requesting a list of towns with aquaculture plans from the MA Division of Marine Fisheries, East Coast Shellfish Growers Association, and Cape Cod Cooperative Extension
- Discussing with Falmouth Marine and Environmental Services staff
- Phone/in person interviews (summarized below) with:
    - Tessa Getchis Connecticut Sea Grant
    - Sebastian Belle, Maine Sea Grant
    - Perry Raso, Ocean State Aquaculture Association
    - David Beutel, RI Coastal Resources Management Council
    - Gregg Rivara, Cornell Cooperative Extension

Aquaculture plans from several coastal towns in southeast Massachusetts were identified. While coastal towns have regulations related to municipal propagation and wild harvest, only the towns listed below have specific plans related to private aquaculture. The following is a bibliography for these Aquaculture Plans:

- Barnstable, MA Shellfish Aquaculture Study (1998) and Three Bays Shellfish Master Plan (2016)
- Dennis, MA Coastal Resources Plan section of the Local Comprehensive Plan (2002)
- Duxbury, MA Aquaculture Management Plan (January 12, 2009)
- Orleans, MA Phase I: Orleans Shellfish Operations and Program Expansion Plan (June 2015)

Based on discussion with staff at Sea Grant programs in Connecticut, Maine, Rhode Island and New York, several state and county-level planning efforts were identified. The following is a bibliography for these plans:

- A Guide to Marine Aquaculture Permitting in Connecticut (2008)
- Rhode Island Shellfish Management Plan (2014)
- The Suffolk County Shellfish Aquaculture Lease Program Management Plan (August, 2009)
- U.S. Atlantic Coast State Shellfish Aquaculture Permitting Information prepared by Paul Zajicek Division of Aquaculture, Florida Department of Agriculture and Consumer Services

The contents of these town and state-level plans are summarized below and elements and methods that are relevant to Falmouth’s Rotational Aquaculture Plan are identified.

Barnstable, MA Shellfish Aquaculture Study (SAS, 1998) and Three Bays Shellfish Master Plan (SMP, 2016)

The Barnstable SAS identifies “areas of least conflict” throughout the town where shellfish aquaculture would be compatible with other uses. To identify these areas, the Barnstable Department of Natural Resources formed a volunteer Public Advisory Group (PAC) to identify and study shellfish aquaculture and multi-user group issues. Members of the PAC represented the spectrum of user groups of the town’s coastal resources. These stakeholders provided information and assessments regarding how the granting of aquaculture leases in different areas might impact the other current uses of the water. A consideration of biological suitability or water quality impacts were not part of this assessment.

Factors that were considered:

- Historic and presently productive shellfish habitat
- Recreational and commercial shellfish harvesting areas
- Shellfish relay areas
- Public shellfish propagation project areas
- Navigation channels
- Mooring fields
- Existing licensed aquaculture sites
- DMF shellfish area classifications
- Anadromous fish runs

Using a consensus approach, the PAC develop draft policies and recommendations for areas throughout Barnstable where private aquaculture would be of minimal impact to other uses. The plan includes maps of the "areas of least conflict" but does not include any details for the factors that were considered. This plan was adopted by Barnstable Town Council. The current lease areas in Barnstable were permitted based on this document.

The Three Bays SMP included the following sections:

- Introduction
- Background: including historical data and reports and a description of current shellfish Initiatives in Three Bays (both municipal propagation and private aquaculture)
- Analysis of food availability and minimum carrying capacity for shellfish based on Massachusetts Estuaries Project water quality data sets and other environmental assessments, and discussions with town Department of Natural Resources and growers
- Quantification of area available for shellfish propagation using GIS analysis of acreage and "Areas of Least Conflict" from 1998 Aquaculture Plan
- Quantification of the overall potential for nitrogen-removal of the shellfish plan

<u>Recommended elements from Barnstable's plans to include in Falmouth's Plan:</u>

- Factors that were considered (mooring fields, existing aquaculture sites, DMF shellfish areas, anadromous fish runs, habitat and resource assessments, food availability, available acreage)
- Maps showing "areas of least conflict"
- Quantification of the nitrogen-removal expected

Dennis Coastal Resources Plan (CRP)

In 2001, the Town of Dennis established an Aquaculture Development Area (ADA) in Cape Cod Bay. While not part of an explicit aquaculture plan, the decision to site private aquaculture in this area was made based on several factors. This beach already allowed access for automobiles and horses, and the flats were not a productive shellfish harvest area. This area is currently managed through local shellfish regulations. In addition, the Dennis CRP includes the following sections:

- Mapping of current coastal areas
- Inventory of town landings/water access
- Goals and policies for protecting public rights of fishing, fowling and navigation, development in FEMA velocity zones, minimize traffic in critical wildlife and plant habitats, and improve coastal water quality to enable shellfishing and swimming and protect shellfish and finfish habitat.
- List of action items with responsible parties

<u>Recommended elements from Dennis' plan to include in Falmouth's Plan:</u>

- Inventory of town landings and water access
- List of action items with responsible parties

Duxbury Aquaculture Management Plan (January 12, 2009)

Sections:

1. Goals and objectives
    - A key reason for developing this plan is the Board of Selectmen moratorium on either the extension of existing shellfish leases to the maximum allowed area of 3 acres, or the permitting of additional shellfish leases.
2. Background on current aquaculture regulations and practices and current lease areas
3. Benefits of aquaculture industry to town
    - Economic multiplier citations provided
4. Impacts of aquaculture industry to town
    - Identification of which town infrastructure (such as boat landings) the aquaculture industry is currently using
    - Suggestions for how to reduce multi-use issues, such as use of rafts for sorting, culling and bagging; consistent and clear buoys that mark lease areas and a waterways guide for boaters that highlights locations of lease areas)
5. Description of existing lease program
6. Discussion of the future of the shellfish lease program
7. Summary of existing knowledge of Duxbury Bay ecology
    - General, qualitative (no carrying capacity estimates made)
    - Recommends a site-specific survey of the Bay's capacity to support shellfish populations
    - References support hypothesis that shellfish aquaculture improves ecological conditions
8. Summary of current uses of Duxbury Bay

9. Discussion of sustainable aquaculture practices for existing lease-holders
    - Need for off-season storage
    - Effect of moratorium on current lease-holders
    - Size of additional areas that should be licensed, including rationale
10. Discussion of licensing new aquaculture areas

- Priority is given to allowing existing industry to mature, and expand to the 3-acre maximum size that was allowed prior to moratorium
- Limited-entry fishery model discussed (new leases are granted when old leases are relinquished)
- Need to study impacts of additional lease areas

<u>Recommended elements from Duxbury's plan to include in Falmouth's Plan:</u>

- Benefits and impacts of aquaculture industry to the town (economic, environmental)
- Summary of existing knowledge of waterbody ecology
- Summary of current uses of waterbodies
- Numerical estimate for additional lease acreage

Orleans, MA Phase I: Orleans Shellfish Operations and Program Expansion Plan (June 2015)

This plan contains the following sections:

- Quantification of the current and historic production from private aquaculture operations in Orleans
- Assessment of whether these leases are making a measurable impact on water quality
- Summary findings from a Shellfish Forum held on June 6, 2015 to review proposed sites for increased shellfish propagation (municipal propagation) in Pleasant Bay and Town Cove
- Action items and responsible parties

<u>Recommended elements from Orleans' plan to include in Falmouth's Plan:</u>

- Summary of input from public hearings
- List of action items with responsible parties

Related activities from other towns

While not formalized in a planning document, Provincetown and Truro are planning to double the area where commercial aquaculture is licensed. Each town now has a 25-acre Aquaculture Development Area (ADA). Truro plans to add 25 more acres adjacent to its existing site, while Provincetown is seeking to add acreage parallel but not adjacent to its site. Because of whale entanglement issues, floating gear will not be permitted in the expanded Truro area, but Provincetown will be expanding into shallower waters that will likely allow the use of floating gear. Whale entanglement issues are not an issue in shallower waters. Any private aquaculture lease within the ADAs still require permits from the local Board of Selectmen and Conservation Commission and, as well as Division of Marine Fisheries and U.S. Army Corps of Engineers.

Summary of Information from Other States

Outside Massachusetts, the permitting authority for aquaculture leases is typically at the state level. Discussions with regulators as well as staff from the Cooperative Extension/Sea Grant programs in Rhode Island, Connecticut and Maine provided insight into the evolution of several state programs. In addition, a comprehensive review of the state-level aquaculture lease programs for the east coast is detailed in the report entitled "U.S. Atlantic Coast State Shellfish Aquaculture Permitting Information". Elements of these approaches have been reviewed for the purpose of informing the Falmouth Rotational Aquaculture Plan. A synthesis of these conversations and related documents is included below.

The lease programs of different states include one or more of the following:

- Maps showing areas within which aquaculture leases may be permitted. These areas are determined after an analysis of natural resources, hydrodynamic/benthic characteristics and potential use conflicts
- Size limits on lease area
- Different classifications of leases (commercial, experimental/commercial viability, recreational, limited-purpose)
- Annual use fees, typically on a per acre basis (from $5 [MA] – $500 [NH] per acre)
- Limits on the number of leases allowed per application
- Shellfish production and reporting requirements
- Renewal periods and renewal fees
- Performance bonds
- Information and filing fees that must be submitted with lease applications
- Public hearing and abutter notification requirements for lease applications
- Permits from other agencies (local, state and/or federal)

As the Town of Falmouth establishes permitting requirements and other requirements for aquaculture, the specific permitting requirements from these programs may be useful to consider.

State-specific Planning in Connecticut, Maryland, Maine, New York and Rhode Island

The Connecticut Department of Agriculture (DOA) regulates the permitting of aquaculture lease sites in state waters. Areas considered suitable for gear-based aquaculture have not been mapped. When an applicant applies for a given location, this area is then publicly advertised and sealed bids are submitted. A threshold requirement for applying for an aquaculture lease is that the areas proposed for private shellfish planting and cultivation must not interfere with any established rights of fishing. Several other permitting authorities are also involved, including the state's Department of Environmental Protection's Office of Long Island Sound Programs and the Army Corp of Engineers. Towns, cities or boroughs are required to set up municipal Shellfish Commissions to manage both wild shellfish resources as well as aquaculture in waters outside the state's jurisdiction. These local Commissions do not have the authority to permit structures, including gear within the coastal waters located inside their "town line". This authority rests with the state DOA, with local Commission comments included as part of the state's permitting process. Local Commissions have the authority for leasing commercial shellfish grounds that have no associated structures or gear and must develop a comprehensive management plan that includes a process for permitting these areas.

In Maine, the state Department of Marine Resources administers the permitting process. Specific aquaculture areas are not mapped. It is up to applicants during the permitting process to present information showing the merits of any site to be considered for a lease. Multiple categories of leases are available, from experimental to large scale commercial.

Maryland's Department of Natural Resources (DNR) was reorganized in 2009 to proactively promote shellfish aquaculture and streamline the permitting process. To help identify suitable lease sites and create the proper maps to accompany an application, the state developed an aquaculture siting tool. This tool is an interactive online map viewer that displays both environmentally sensitive areas as well as potential conflicts with existing commercial and recreational uses. Although growers can apply for as much acreage as they believe they need, they must provide production plans. When granted, leases then include planting requirements that must be met annually and proof of insurance. Nonresidents and business entities are also allowed to apply for leases.

In New York, the state regulates lands under water except for coastal ponds, which are controlled by towns. Recent regulatory changes have given Suffolk County control of areas previously regulated by the state. The County now controls the location, extent and intensity of aquaculture in approximately 100,000 acres in Peconic Bay and Gardiners Bay. The Suffolk County Shellfish Aquaculture Lease Program Management Plan (2009) describes implementation details of the County program for both new and existing growers. New shellfish farms are permitted as either five or ten-acre parcels. These new leases are limited to a total of 60 additional acres per year for ten years, in addition to the current area or 2.9% of the area under County lease jurisdiction.

A key feature of this program is the Shellfish Cultivation Zone map which defines the specific areas where shellfish leases can be issued, under the phasing constraints listed about. This map was developed by reviewing environmental and other data to guide lease siting, such as:

- Habitat and resource assessments
- Shellfish productivity and abundance
- Water quality data
- Socioeconomic data
- Maritime traditions

Multiple stakeholder meetings with individuals as well as groups were held to inform this mapping effort. Through proactive mapping of possible lease areas, clear limits on lease size and number, and a streamlined permitting pathway, the County both promotes private aquaculture and explicitly manages use conflicts. The program also provides non-commercial shellfish cultivation leases for experimental, educational, and shellfish resource restoration purposes to municipalities, researchers, and non-profit organizations. Lease applicants must also obtain a shellfish culture permit from NYSDEC. The towns of Islip, Babylon and Brookhaven control the majority of underwater lands in Great South Bay and are currently developing lease programs for this area that will likely be patterned after the Suffolk County approach.

In Rhode Island (RI) the Coastal Resources Management Council (CRMC) regulates all waters that are submerged and permits aquaculture activities within these waters, including coastal ponds. Aquaculture is not allowed in intertidal areas. Towns may submit Harbor Management Plans for waters adjacent to the town, where they can comment on aquaculture. The CRMC approves these Harbor Management Plans, which are expected to be consistent with the 2014 RI Shellfish Management Plan (SMP).

The SMP is a state-level comprehensive plan for shellfish, with a focus on preserving and enhancing the wild stock of species such as quahogs, soft-shelled clams, oysters, blue mussels and other native species. The SMP was developed as a collaborative effort amongst regulators, scientists, commercial interests, non-profit organizations and citizens over a two-year period. Large sections of this plan are dedicated to summarizing the scientific understanding related to wild shellfish populations in the state, in order to develop management recommendations to protect and enhance these wild shellfish resources. Although the SMP does not include specific regulations, it contains numerous recommendations that were developed by this broad group of stakeholders that worked together as a team to draft this plan.

Key features of the Rhode Island SMP include:

- Clearly articulated goals and objectives for the state's shellfish resources in general and the planning process in particular
- An identification of urgent issues and early action items accomplished through the SMP process
- Detailed descriptions of the physical, biological, social, and economic aspects of Rhode Island's shellfish resource, including information on the standing stock of select species
- Summary of the status of both wild harvesting and aquaculture, with an identification of trends
- Summary of regulations pertaining to shellfish in RI
- Policy and management recommendations, including an Adaptive Management Approach
- Development of use maps developed by stakeholders during several facilitated workshops

These maps document and highlight the myriad of human uses and activities currently occurring within Narragansett Bay and the coastal ponds. The goals of mapping human uses were to examine how the Bay and coastal ponds are used and by whom, and also to better understand utilization patterns and interactions. Furthermore, the effort aimed to enhance existing tools and resources available to state agencies to inform management decisions about water-related uses.

<u>Recommended elements from state plans to include in Falmouth's Plan:</u>

- Maps showing appropriate areas for aquaculture evaluated and finalized through a stakeholder process
- Clearly articulated goals for the Town's shellfish resources

The outline below incorporates the recommended elements from the aquaculture plans and other planning documents reviewed, as well as the specific requirements from Falmouth's Request for Proposals for its aquaculture plan.

Section 2. Resource Assessments and Potential Aquaculture Areas

Section 2A. Planning Area

Falmouth is home to 14 estuaries with Massachusetts Estuaries Project Reports. The following are included in the Falmouth Rotational Aquaculture Plan:

1. Megansett Harbor
2. Rands Canal
3. Fiddlers Cove
4. Wild Harbor
5. West Falmouth Harbor
6. Quissett Harbor
7. Salt Pond
8. Falmouth Harbor
9. Little Pond
10. Great Pond
11. Green Pond
12. Bournes Pond
13. Waquoit Bay
    - Childs River/Eel Pond
    - Seapit River

Estuary delineation is consistent with the Massachusetts Estuaries Project (MEP) mapping conventions. The specific sites recommended for aquaculture within these waterbodies are described in Section 2, including the process used for initial site evaluations. Oyster Pond is not included because it is maintained at a salinity of approximately 5 parts per thousand which will not support shellfish growth.

Falmouth's Rotational Aquaculture Plan concentrates on locations ***within the Town's estuaries*** for private growing operations. Note that sites in Megansett Harbor and Great Pond are associated with offshore locations due to the seasonal nature of harvesting. Seed grown in these conditionally-approved areas is required to move to open areas to be grown to harvestable size. Focusing aquaculture in the Town's estuaries benefits commercial wild harvesters, aquaculture growers and Town as a whole. These advantages include:

- Linking aquaculture sites to locations for enhanced municipal propagation of hard clams and other species
- Removing some of the nitrogen that is polluting these eutrophic waterbodies
- Providing locations to aquaculture growers with better growing conditions relative to offshore sites in Buzzards Bay and Vineyard Sound, such as:
    - Higher food availability, which allows a higher density of shellfish to be grown and lowers the overall gear required for a given number of shellfish
    - Warmer waters, creating a longer growing season
    - Protected and more safe working conditions

- Easier access

Falmouth's estuaries are rich in algae, which is both a problem and a resource. In terms of water quality, algae are a symptom of nitrogen enrichment. For filter-feeding shellfish, algae are food. Bringing filter-feeders into estuaries to remove algae benefits all the users of these natural resources and is an important part of the Town's Comprehensive Wastewater Management plan. Growers benefit by farming areas with ideal conditions for shellfish cultivation, which reduces the time-to-market for their product, and lowers overall costs per unit of shellfish sold. Commercial harvesters benefit by having enhanced propagation occur concurrent with aquaculture activities. The specific permitting approach that enables these key stakeholders to all profit from enhanced aquaculture in Falmouth is detailed in Section 3.

Section 2B. Data Sources

This habitat and resource assessments conducted for each of the estuaries discussed in this report are based on data from the following sources:

- Division of Marine Fisheries (DMF) Designated Shellfish Growing Area Maps
- DMF Shellfish Suitability Area Maps
- MA Department of Environmental Protection (MA DEP) Eelgrass Maps
- Massachusetts Estuaries Project Reports (MEP, dates vary)
- Town of Falmouth Recreational and Commercial Shellfish Areas
- Shellfish Habitat Assessment Maps for West Falmouth Harbor, Childs/Eel Pond and Green Pond
- Draft Green Pond Harbor Management Plan (July 2009)
- Falmouth Geographic Information System (GIS)

Specific data is sourced as described below.

Information regarding the classification of shellfish growing areas, as well as locations of suitable habitats and eelgrass beds comes from DMF. According to the MassGIS website, DMF's Shellfish Suitability Areas "delineate areas that are ***believed*** to be suitable for shellfish based on the expertise of the Massachusetts Division of Marine Fisheries (DMF), the opinion of local Massachusetts Shellfish Constables, and information contained in maps and studies of shellfish in Massachusetts. The areas covered include sites where shellfish have historically been sighted, but may not currently support any shellfish. ***The shellfish suitability areas were not verified in the field and the boundaries were not surveyed***." (emphasis added). DMF classifies these potential shellfish growing areas for management with respect to harvest for direct human consumption, in accordance with the National Shellfish Sanitation Program. Classifications include approved, conditionally approved, restricted, conditionally restricted and prohibited. Sections of Falmouth's estuaries fall into one of three classifications: approved, conditionally approved or prohibited. Falmouth Harbor is classified as restricted. Approved areas are open year-round for the harvest of shellfish stock for human consumption. Conditionally approved areas close during certain periods of the year due to environmental factors. During these closed periods, harvest of shellfish is prohibited. In prohibited areas, harvest of shellfish is not permitted. Current aquaculture regulations prohibit private aquaculture in areas that are conditionally approved and/or prohibited.

The delineation of habitats that are appropriate for specific shellfish species are based on the DMF Designated Shellfish Suitability Maps, with additional field verification from the town shellfish constable. Ten species of shellfish are included in the DMF assessments:

- American Oyster
- Bay Scallop
- Blue Mussel
- European Oyster
- Ocean Quahog
- Quahog
- Razor Clam
- Sea Scallop
- Soft-shelled Clam
- Surf Clam

The areas shown on DMF's maps include sites where shellfish have been observed since the mid-1970's, but may not currently support any shellfish. They are believed to be suitable for shellfish based on the expertise of DMF and local Shellfish Constables, input from commercial fishermen, and other studies. DMF advises that site specific surveys should be conducted to verify habitats because habitats and water quality change over time. Site specific surveys shellfish surveys have been conducted in West Falmouth Harbor, Little Pond, Green Pond, and Childs/Eel Pond and these data are included as part of this review.

The DEP Eelgrass Mapping Project began in 1994 to provide systematic and comprehensive documentation of the aerial extent of the state's eelgrass resources. These data also show the extent of habitat loss over several decades. The MEP Reports are a comprehensive review of the water quality of Falmouth's estuaries. Information on parameters such as nitrogen species, chlorophyll-*a*, dissolved oxygen and sediment type is derived from these reports. Relevant habitat and infrastructure information for Green Pond also came from the Draft Green Pond Harbor Management Plan. Infrastructure and public use areas were obtained using the town's GIS system and field visits. The purpose of this resource assessment was to identify possible areas for shellfish aquaculture.

Section 2C. Decision Support Tool for Estuary Evaluations

To facilitate a systematic and objective evaluation of Falmouth's estuaries for private aquaculture license sites, a Decision Support Tool was developed. The process of customizing this Decision Support Tool for the Falmouth Rotational Aquaculture Plan occurred over two workshop meetings with the Shellfish Working Group (SWG). This tool includes a number of criteria that address the environmental, land use and other characteristics of each estuary.

The initial ranking system was designed as a point-based system to quantify how well each location met a specific criterion. If an estuary was fully suitable based on the criterion being ranked it was assigned a numerical value of 3, if the site was mostly suitable based on the criterion being ranked it was assigned a ranking of 0, and if the site was unsuitable it was assigned a ranking of -3. Using this initial approach, the SWG reviewed ranked three initial sites, including Megansett Harbor, Rands Canal and Fiddlers Cove based on water quality data from the MEP Reports, eelgrass maps from MA DEP, shellfish suitability and other GIS maps from DMF, preliminary sediment data and information provided by Town staff and SWG members.

During this ranking exercise, it was determined that the criteria were better evaluated as threshold issues, using a yes/no or high/medium/low ranking system. The Decision Support Tool was revised based on this input and each of Falmouth's estuaries was then ranked using this approach. Figure 1 shows the final criteria that were used.

Criteria
Overriding/threshold considerations
Prohibited area
Lack of space (due to eelgrass, moorings, navigation)
Aesthetic/abutter compatibility (gear type)
Use conflict (navigation, boating, swimming, other)
Currently used for municipal oyster propagation
Successful shellfish cultivation likely (environmental)
Implementation Factors
Private landowner partner needed
Grow-out to harvestable size allowed (DMF)
Wild harvest area
Start/end of private growing season
Public access available
Nitrogen removal benfits

Figure 1. Decision Support Tool Criteria

2C.1: Definitions

Prohibited area: the harvesting of shellfishing is not allowed due to bacterial and other considerations. These areas are considered inappropriate for private aquaculture.

Lack of space: an assessment of whether the amount of waterbody surface area is sufficient for private aquaculture, and whether expansion potential exists. Key considerations are presence of eelgrass, moorings, navigation channels and other proximate uses.

Aesthetic /abutter compatibility (gear type): the visual impression that the project will have on vistas around the site and the likelihood that private aquaculture can occur without significant objections from adjacent landowners and residents.

Use conflict: the likelihood that the proposed shellfish demonstration can occur without impeding the other activities currently taking place at proposed demonstration sites. This criteria seeks to evaluate whether there will be strong objections from the community of people who use the waters nearby. The lack of space criterion (above) is more area-based, while this criterion seeks to understand stakeholder perceptions.

Currently used for municipal oyster propagation: the presence of a successful program for municipal propagation was discussed and it was concluded that these existing Town programs were more appropriate than private aquaculture in West Falmouth Harbor, Falmouth Harbor and Little Pond. Bournes Pond seemed suitable for both private aquaculture as well as continued municipal propagation.

Successful shellfish cultivation likely: the environmental conditions needed to support shellfish growth are available. Key parameters include chlorophyll *a*, dissolved oxygen (DO), and salinity, and absece of a population of predators (or the ability to control through the use of gear).

Private landowner partner needed: the need for abutting landowner because of access issues or because the estuary was created by dredging and the land under the water is privately-owned.

Grow-out to harvestable size allowed: certain sites are not always open to shellfishing, which requires a relay out of the area for grow-out to harvestable size.

Wild Harvest area: there are populations (standing stock) of species that are currently harvested, so aquaculture activity in this location cannot be permanent.

Public access available: locations are available from which aquaculture sites can be accessed, operated and maintained.

Start of growing season: the month in which the conditional area closes to the wild harvest of shellfish, allowing private aquaculture to operate without impacting this activity.

Nitrogen-removal benefits: the relative role of shellfish in meeting the target nitrogen-removal goal as calculated in the MEP Reports. If the estuary is part of the Town's Comprehensive or Targeted Wastewater Management Plan (CWMP/TWMP), or if the nitrogen-reduction target is less than 1500 kg N/year, the estuary was ranked HIGH for this criterion.

2C.2: Qualitative Ranking for Each Criterion

Each of the criterion reviewed was ranked using either a yes/no or high/medium/low assessment. For the overriding/threshold considerations, certain rankings were used to determine whether a particular estuary should be removed for consideration for private aquaculture as follows:

- Prohibited area criterion: if ranked YES, this criterion takes estuary off list for private aquaculture areas, with note that if classification changes, estuary could be re-reviewed for aquaculture
- Lack of space criterion: if ranked YES, this criterion takes estuary off list for private aquaculture areas

- Aesthetic/abutter compatibility criterion: If ranked LOW, this criterion takes estuary off list for aquaculture areas
- Use conflict criterion if ranked HIGH, this criterion takes areas of estuary off list for aquaculture areas
- Currently used for municipal oyster propagation: If ranked YES, this criterion takes estuary off the list for aquaculture areas
- Successful shellfish cultivation likely: if ranked NO, this criterion takes estuary off list for aquaculture areas

Criteria important to implementation were also evaluated to guide future planning and ranked as follows:

- Private landowner partner needed (YES/NO)
- Grow-out to harvestable size (YES/NO)
- Wild harvest (YES/NO)
- Public access available (NEAR/MID/NO) indicating distance from public access
- Start of growing season (MONTH) helps gage when private aquaculture operations can begin seasonally
- Nitrogen-removal benefits (HIGH/LOW) relate to the target nitrogen load reductions from the MEP Reports

<u>2C.3: Results of Decision Support Tool Evaluations</u>

Appendix A contains the Decision Support Tool results. Based on the ranking of the various criteria in the Decision Support Tool, the following estuaries are initially found to be appropriate for private aquaculture:

1. Megansett Harbor
2. Rands Canal
3. Quissett Harbor
4. Great Pond
5. Bournes Pond
6. Waquoit Bay
   - Childs River/Eel Pond
   - Seapit River

Municipal oyster propagation occurs in these estuaries:

1. West Falmouth Harbor
2. Falmouth Harbor
3. Little Pond
4. Green Pond
5. Bournes Pond

Table 1 summarizes the acreage and percent of waterbody that the potential aquaculture areas shown in Figures 1 - 12 represent.

Table 1: Summary of Potential Areas for Aquaculture by Estuary

Potential Aquaculture Site	Total Waterbody Area (acres)	Approximate Area of Polygon (acres)	Percent of Waterbody	Map Name
Megansett Harbor	540	4.0	1%	Megansett Harbor, Fiddlers Cove and Rands Canal
Rands Canal	10	0.25	2%	Megansett Harbor, Fiddlers Cove and Rands Canal
Quissett: Off National Academy	100	2.0	2%	Quissett Harbor
Upper Great Pond: East		1.0		Little Pond, Great Pond
Upper Great Pond: West		2.5		Little Pond, Great Pond
Lower Great Pond: North		3.0		Little Pond, Great Pond
Lower Great Pond: South		3.5		Little Pond, Great Pond
Great Pond (All)	269	10.0	4%	
Bournes Pond: Conditional Area		2.5		Bournes Pond
Bournes Pond: Northeast		11.0		Bournes Pond
Bournes Pond: South		2.5		Bournes Pond
Bournes Pond (All)	153	16.0	10%	
Eel Pond: Northwest (Off Eel River Rd)		0.5		Waquoit Bay and Eel Pond
Eel Pond: Southwest		1.0		Waquoit Bay and Eel Pond
Eel Pond: Off Seacoast Shores		1.0		Waquoit Bay and Eel Pond
Eel Pond: Washburn Northwest		4.0		Waquoit Bay and Eel Pond
Eel Pond: Washburn Mid		3.0		
Eel Pond: Washburn Southwest		5.0		
Eel Pond: Cove in Washburn		2.5		Waquoit Bay and Eel Pond
Eel Pond: Off Seapit Road		2.0		Waquoit Bay and Eel Pond
Eel Pond Offshore		5.0		Waquoit Bay and Eel Pond
Eel Pond (All)	278	24.0	9%	
Waquoit Bay Main (All)	679	0.0	0%	Waquoit Bay and Eel Pond

Each of Falmouth's twelve estuaries is described in detail in Section 2D, and includes a discussion of the evaluation made for private aquaculture.

Section 2D. Estuary Discussions and Evaluations

Megansett Harbor

Figure 1 shows eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches, boatyards and yacht clubs are also marked.

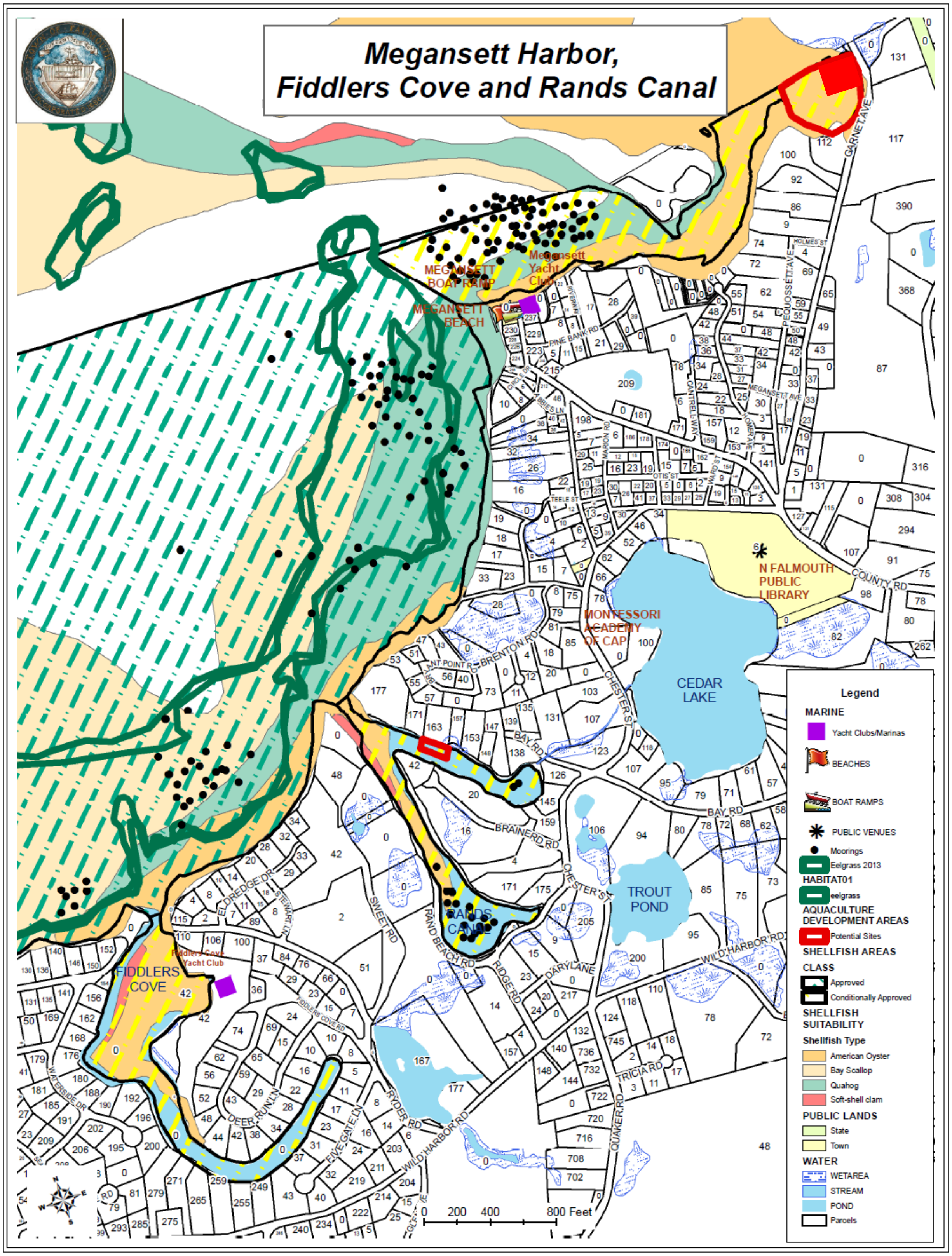


Figure 1. Megansett Harbor, Rands Canal and Fiddlers Cove: Map of Habitat, Infrastructure, Public Uses and Potential Aquaculture Areas

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for Megansett/Squeteage Harbor (2015) include:

Eelgrass and Sediment Type

As shown in Figure 1, much of the Megansett main basin contains eelgrass beds. Historically, these beds were much larger, and included an area in Squeteage Harbor. Areas that do not presently contain eelgrass, nor have a history of eelgrass include the western shore off Pequossett Ave (southern extension of Lawrence Island) and the channel into Squeteage Harbor. The bottom sediment in these areas is mostly sand.

Shellfish/finfish

As shown in Figure 1, DMF Shellfish Growing Area maps classify most of Megansett Harbor as approved, with the channel that enters Squeteague Harbor as conditionally approved. There is an active population of oyster drills, conch and starfish throughout this area, which is considered suitable habitat for quahogs and sea scallops. It is likely that oysters would also grow here. Commercial and recreational wild harvest of quahogs occurs in Megansett Harbor.

Infrastructure/Public Uses

Megansett Harbor is a multi-use recreation area. As shown in Figure 1, on the west side of County Road, there is a public beach, boat landing with ramp and parking lot with approximately 40 parking spaces. Megansett Yacht Club is located on the east side of County Road. There are 80 private moorings and 3 boatyard/yacht club moorings in the inner harbor and 93 private moorings in the outer harbor. Private moorings are administered through the town. The channel into Squeteague Harbor is narrow and surrounded by shallow sand flats. This recreation area is heavily used in the summer for boating, sailing lessons, and swimming.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for Megansett/Squeteague Harbor. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in this system (between 3 ug/L and 46 ug/L in Megansett Harbor and 4 ug/L and 32 ug/L in Squeteague Harbor). In Megansett Harbor, data loggers were installed at three monitoring stations over a 42-day period during July, August and September. Average Chl-*a* concentrations of 7 ug/L, 5.3 ug/L and 4.7 ug/L are reported, with levels below 5 ug/L 59% of the deployment period. In Squeteague Harbor, data loggers were also installed at three monitoring stations in July. Average Chl-*a* concentrations of 11.8 ug/L, 11.2 ug/L and 11.6 ug/L are reported, with levels below 5 ug/L an average of 3% of the deployment period, which varied from 26 to 41 days. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water. According to the MEP Report, bottom water dissolved oxygen concentrations do not typically decline below 4 mg/L. This indicates that oxygen should not be a limiting factor in shellfish propagation.

Table 2. Executive Summary Table from MEP Report for Megansett Harbor

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Wild Harbor estuarine system in Falmouth, Massachusetts.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
Megansett Harbor	18.978	15.760	5.556	-23.545	-2.229	-17.0%
Megansett Channel	3.699	3.422	0.386	-0.669	3.140	-7.5%
Squeteague Harbor	9.263	8.741	1.000	0.146	9.888	-5.6%
Combined Total	**31.940**	**27.924**	**6.942**	**-23.545**	**10.799**	**-12.6%**

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Target nitrogen removal for Megansett Harbor: (31.94 kg/day – 27.924 kg/day) = 4.016 kg/day x 365 days/yr = 1,466 kg/yr

Based on Table 2, approximately 1,470 kg N per year must be removed for Megansett Harbor to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figure 1 shows a potentially suitable area for shellfish aquaculture off the shore between Homer Ave and Garnet Avenue (~4 acres). This specific area near Squeteague Harbor subembayment are considered appropriate for private aquaculture based on the six Overriding/Threshold Consideration criteria. In summary: this location is not within a prohibited area; this site does not impinge on eelgrass, moorings and navigation channels; aesthetic concerns are not ranked high; use conflicts are not ranked high; municipal propagation of oysters does not occur in this area; and it is likely that shellfish could be successfully cultivated at this location. Key implementation considerations include: shellfish cannot be grown to harvestable size; sections are used for wild commercial harvest so a survey for productive bottom is needed; the closure period within which private aquaculture could occur is moderate (between July 1 and September 30); public access for boat launching is nearby and there is a public boat landing; and the value of shellfish cultivation for nitrogen-removal is high.

The seed that is cultivated in these conditional areas must be moved to open grow-out areas after the first growing period that is determined by the closure period for wild harvesting. These final grow-out areas may either be within existing offshore grants, or be in new licensed sites in Buzzards Bay that will be identified as part of the permitting process.

Rands Canal/Fiddlers Cove

Figure 1 shows eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked.

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report (2013) for Rands Canal/Fiddlers Cove include:

Eelgrass and Sediment Type

As shown in Figure 1, much of area outside the entrance to Fiddlers Cove and Rands Canal in Buzzards Bay contains eelgrass beds. Neither estuary currently contains eelgrass beds, nor do these systems have a history of eelgrass. The bottom sediment along the shore and in the center closest to Buzzards Bay is mostly sand, with soft sediment found in the middle and closer to the head of these systems.

Shellfish/finfish

As shown in Figure 1, DMF Shellfish Growing Area maps classify both Rands Canal and Fiddlers Cove as conditionally approved. Fiddler Cove and Rands Canal are considered suitable habitat for quahog and soft-shelled clam. Rands Canal is also considered suitable for oysters, which would likely grow in Fiddlers Cove as well, as a natural set of oysters was observed on the rip-rap in 2015. A fish ladder for alewife was built at the head of Rands Canal (east), where the Canal connects to a stream under Bay Road. The town does not have any commercial and/or recreational wild harvest areas within Rands Canal or Fiddlers Cove.

Infrastructure/Public Uses

Rands Canal and Fiddlers Cove are manmade, boat basins that are about 100 feet wide, with no public access from the land. There are approximately 33 private docks in Fiddlers Cove and six in Rands Canal. There are 5 boatyard moorings and 15 private moorings in Rands Canal. Private moorings are administered through the town. There is a private marina located in Fiddlers Cove, with a private upweller located under one of the docks. This area is heavily used for boating in the summer.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for Rands Canal and Fiddlers Cove. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in these systems (between 4 ug/L and 45 ug/L in Fiddler's Cove and 3 ug/L and 25 ug/L in Rands Canal). In Fiddlers Cove, data loggers were installed at two monitoring stations over a 41-day period during June, July and August. Average Chl-*a* concentrations of 15.2 ug/L and 10.5 ug/L are reported, with levels below 5 ug/L 2% of the deployment period. In Rands Canal, data loggers were installed at two monitoring stations in July. Average Chl-*a* concentrations of 8.3 ug/L and 6.2 ug/L are reported, with levels below 5 ug/L an average of 24% of the 26 -day deployment period. Periodic algae blooms occurred during the data collection period in both systems. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

According to the MEP Report, bottom water dissolved oxygen concentrations do not typically decline below 4 mg/L in either Fiddlers Cove or Rands Canal. This indicates that oxygen should not be a limiting factor in shellfish propagation.

Table 3. Executive Summary Table from MEP Report for Rands Canal and Fiddlers Cove

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Fiddlers Cove and Rands Harbor estuarine systems in Falmouth, Massachusetts.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
Rands Harbor	6.074	4.410	0.142	0.582	5.134	-27.4%
Fiddlers Cove	4.332	3.368	0.184	1.208	4.760	-22.2%
Combined Total	**10.406**	**7.778**	**0.326**	**1.790**	**9.894**	**-25.2%**

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Target nitrogen removal for Rands Harbor (Canal): (6.074 kg/day – 4.410 kg/day) = 1.664 kg/day x 365 days/yr = ~ 607 kg/year
Target nitrogen removal for Fiddlers Cove: (4.332 kg/day– 3.368 kg/day) = 0.964 kg/day x 365 days/year = ~ 352 kg/year

Based on Table 3, approximately 607 kg N per year must be removed for Rands Canal and about 352 kg/N per year for Fiddlers Cove to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figure 1 shows a potentially suitable area for shellfish aquaculture in Rands Canal. This specific area is to be determined based on landowner partner and is considered appropriate for private aquaculture based on the six Overriding/Threshold Consideration criteria. In summary: this location is not within a prohibited area; this site does not impinge on eelgrass, moorings and navigation channels; aesthetic concerns are not ranked high; use conflicts are not ranked high; municipal propagation of oysters does not occur in this area; and it is likely that shellfish could be successfully cultivated at this location. Key implementation considerations include: a private landowner partner is needed due to the ownership structure of this dredged basin; shellfish cannot be grown to harvestable size; sections are used for wild commercial harvest so a survey for productive bottom is needed; the closure period within which private aquaculture could occur is moderate (between May 1 and September 30); public access for boat launching is reasonably close and there is a public boat landing; and the value of shellfish cultivation for nitrogen-removal is high.

Wild Harbor/Wild Harbor River

Figure 2 shows eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked.

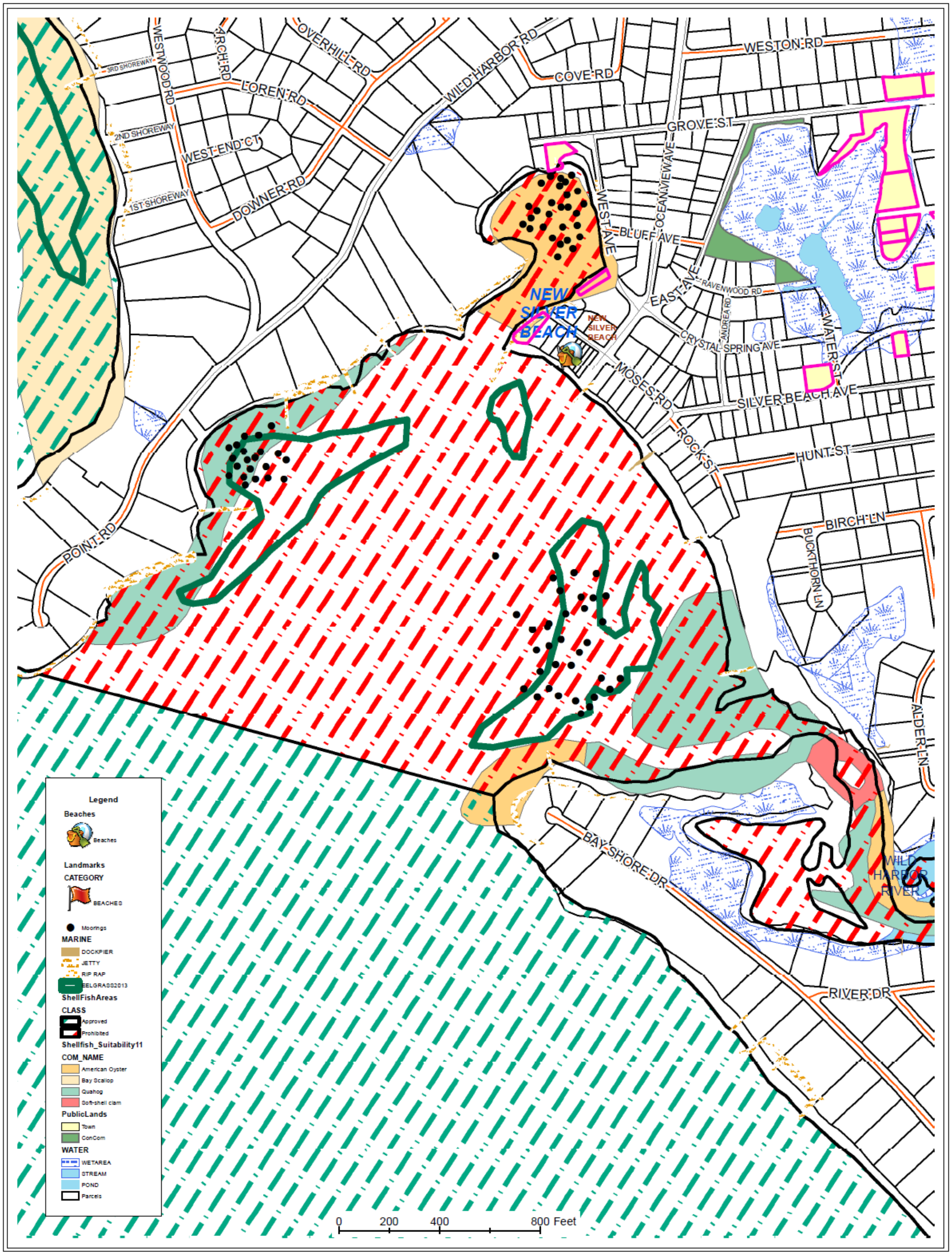


Figure 2. Wild Harbor and Wild Harbor River: Map of Habitat, Infrastructure and Public Uses

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for Wild Harbor include:

Eelgrass and Sediment Type

As shown in Figure 2, eelgrass is found along the shores of Wild Harbor, but the beds are smaller than the historic areal coverage. Sediment is mostly sandy. The inner Wild Harbor boat basin is a manmade feature created by dredging and bulkhead construction. Eelgrass has not been found historically in this relatively deep, depositional basin. Sediment is fine grained and rich in organic matter (muck). There is not a record of eelgrass in Wild Harbor River because it is predominantly a salt marsh. As is the case with most salt marsh systems, the Wild Harbor River sediment is rich in organic matter and becomes very shallow at low tide.

Shellfish/Finfish

As shown in Figure 2, DMF Shellfish Growing Area maps classify both Wild Harbor and Wild Harbor River as prohibited. These areas are considered suitable habitat for quahogs, with a small section at the entrance to Wild Harbor River suitable for soft-shelled clams. The town does not have commercial and/or recreational wild harvest area within the Wild Harbor system.

Infrastructure/Public Uses

Wild Harbor is a multi-use recreation area. As shown in Figure 2, at the end of Ocean View Avenue, there is a public beach, and small parking lot. Wild Harbor Yacht Club is located off Wild Harbor Road and abuts Grove Street to the south. There are 2 yacht club moorings and 36 private moorings in the Wild Harbor boat basin. Private moorings are administered through the town. This recreation area is heavily used in the summer for boating, sailing lessons, and swimming. Wild Harbor River is used by non-motorized boats, primarily by abutters due to lack of public access.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for the Wild Harbor System. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in both the inner and outer harbor (between 2 ug/L and 30 ug/L). In Wild Harbor, data loggers were installed at two monitoring stations over a period ranging from 28 to 41 days during June, July and August. These two locations have very different patterns of Chl-*a* availability, with average concentrations of 9.4 ug/L reported in the inner harbor and 3.8 ug/L in the outer harbor. Chl-*a* levels fall below 5 ug/L 12% of the deployment period in the inner harbor and 84% of the deployment period in the outer harbor. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

According to the MEP Report, bottom water dissolved oxygen concentrations do not typically decline below 4 mg/L in the inner harbor and 5 mg/L in the outer harbor. This indicates that oxygen should not be a limiting factor in shellfish propagation.

Table 4. Executive Summary Table from MEP Report for Wild Harbor

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Wild Harbor estuarine system in Falmouth, Massachusetts.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
Wild Harbor	10.326	4.552	1.033	-10.232	-4.647	-55.9%
Wild Harbor River	11.825	10.062	0.447	-0.359	10.150	-14.9%
Dam Pond Stream	1.507	1.507	--	--	1.507	0.0
Combined Total	**23.658**	**16.121**	**1.480**	**-10.591**	**7.010**	**-31.9%**

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Wild Harbor: (10.362 kg/day – 4.552 kg/day) = 5. 774 kg/day x 365 days/yr = ~ 2108 kg/year
Wild Harbor River: (11.825 kg/day – 10.062 kg/day) = 1.763 kg/day x 365 days/yr = ~ 643 kg/year
Target nitrogen removal for Wild Harbor System: (23.658 kg/day – 16.121 kg/day) = 7. 537 kg/day x 365 days/yr = ~ 2751 kg/year

Based on Table 4, approximately 2751 kg N per year must be removed for Wild Harbor to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figure 2 is a summary map that does not show any suitable areas for shellfish aquaculture in the Wild Harbor system. Because this area is closed to shellfishing and is a heavily used boat basin, there is lack of space and use conflicts are ranked high. This area would best support additional Town upwellers.

a busy boat basin,.

West Falmouth Harbor

Figure 3 shows eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked. A field assessment of sediment type has been completed for West Falmouth Harbor and is also included.

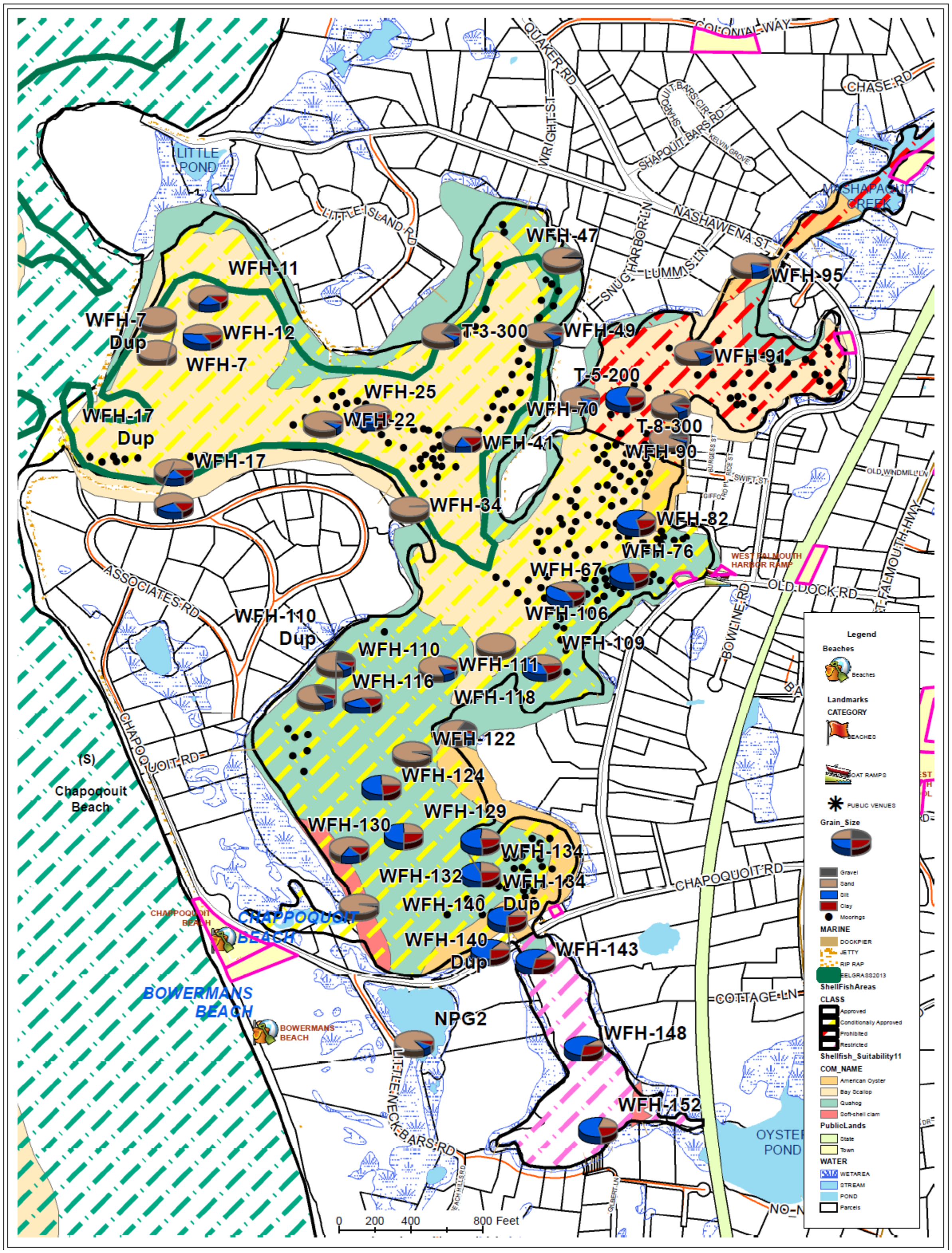


Figure 3. West Falmouth Harbor: Map of Habitat, Infrastructure and Public Uses

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for West Falmouth Harbor include:

Eelgrass and Sediment Type

As shown in Figure 3, Eelgrass beds are found in patches throughout West Falmouth Harbor. Historically, eelgrass beds were larger and contiguous. Sediment in many areas is fine grained and rich in organic matter (muck). There is sandy bottom in a few sections of West Falmouth Harbor, most notably near Chapoquoit Island.

Shellfish/finfish

As shown in Figure 3, DMF Shellfish Growing Area maps classify the main basin of West Falmouth Harbor as conditionally approved, Snug Harbor as prohibited and Harbor Head as restricted. These areas are considered suitable habitat for quahogs and oysters. Commercial and recreational wild harvest of quahogs and oysters occurs in several areas within West Falmouth Harbor. Additional detail on sediment types is available for West Falmouth Harbor from a habitat assessment that was conducted in 2008. The GIS layer that was developed to summarize the results of this data collection effort is included in Figure 3.

Four species of shellfish were assessed as part of this work, including: quahogs (Mercenaria mercenaria), bay scallops (Argopecten irradians), American oysters (Crassostrea virginica), and soft shell clams (Mya arenaria). Prior to the start of field efforts, the entire Harbor area was gridded into north/south and east/west transects spaced 100 feet apart using a large scale orthophoto image. Each intersection was assigned a number (WFH1 – WFH750) and was considered a potential sampling station. Of the 750 potential sampling sites, 125 were randomly selected and 25 specifically chosen (for larger areas missed by random selection or special focus areas) for analysis of shellfish and eelgrass presence or absence (150 stations). The shoreline areas were also surveyed by wading at 100 foot intervals along 100-, 200-, and 500- foot long linear transects that ran parallel to the shore, and were sampled at a distance of 100 feet from mean high water if possible. Each of these linear transects included one “shore normal” transect which ran perpendicular to the shore, with sampling stations at the intertidal area as well as the mid-point of one transect station (e.g. Transect 1 at the 300-foot station was sampled at 50 feet from shore, 25-feet from shore, and at the intertidal area). A total of seventeen (17) linear transects with three (3) to eight (8) stations each were sampled for shellfish throughout the Harbor system, for a total of 120 shoreline transect stations. A total of 270 stations were sampled for shellfish throughout the West Falmouth Harbor area. Ten shellfish stations representing all areas of the West Falmouth Harbor system were chosen for analysis of one benthic grab to determine absence/presence of benthic species indicative of disturbed or healthy habitat conditions.

Sediment type and oxygen conditions were also evaluated using the apparent Redox Potential Discontinuity (aRPD) depth method. Oxidized benthic sediments are light in color, then turn darker as the sediments show signs of anoxic conditions. The change between light to dark sediment is termed the aRPD depth. In general, anoxic or hypoxic sediments will have no or shallow aRPD depths, respectively, and more oxygenated sediments will have deeper aRPD depths. Samples were analyzed for total organic carbon (TOC) and grain-size.

Infrastructure/Public Uses

West Falmouth Harbor is a multi-use recreation area. As shown in Figure 3, There is a town dock and boat ramp off Old Dock Road, and a public beach with a large parking lot at the end of Chapoquoit Road. The harbor side of Chapoquoit beach is also a popular area. Chapoquoit Yacht Club is located off Associates Road. There are 9 boatyard/yacht club moorings and 268 private moorings in West Falmouth Harbor (95 in the inner harbor and 173 in the outer harbor). Private moorings are administered through the town. This recreation area is heavily used in the summer for boating, sailing lessons, and swimming.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for West Falmouth Harbor. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in both Snug, and the outer harbor (between 2 ug/L and 22 ug/L). In West Falmouth Harbor, data loggers were installed at three monitoring stations over a period of 22 days in July. Two loggers are in the outer harbor and one is in Snug Harbor. Two of these three locations have comparable patterns of Chl-*a* availability, with average concentrations of 7.64 ug/L reported in Snug harbor and 5.28 ug/L in the south basin of the outer harbor. The north basin of the outer harbor has an average Chl-*a* of 4.01 ug/L. Chl-*a* levels do not fall below 5 ug/L during the deployment period in Snug Harbor but do fall below 5 ug/L in the northern section of the outer harbor. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

According to the MEP Report, bottom water dissolved oxygen concentrations do not typically decline below 4 mg/L in either Snug Harbor or the outer harbor. This indicates that oxygen should not be a limiting factor in shellfish propagation.

The MEP Report for West Falmouth Harbor was finalized in 2006, prior to substantial improvements to the town's wastewater treatment facility (WWTF). This report assumes that 70% of the load to West Falmouth Harbor comes from the WWTF. Equipment upgrades at the WWTF have reduced the nitrogen concentration of the WWTF's effluent from the 23.5 mg N/L that was used for load calculations in the MEP Report to 3 mg N/L. A new MEP model run is required to determine the actual nitrogen-removal target based on this change, as well as other factors.

Table 5: Summary Table from MEP Report for West Falmouth Harbor

Table VIII-3. Comparison of sub-embayment ***total watershed loads*** (including septic, runoff, and fertilizer, and the WWTF) used for modeling of present and threshold loading scenarios of the West Falmouth Harbor system. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	threshold load (kg/day)	threshold % change
Outer West Falmouth Harbor	1.690	1.359	-19.6%
Inner West Falmouth Harbor	10.386	5.301	-49.0%
Harbor Head	1.085	0.592	-45.5%
Oyster Pond	1.359	0.718	-47.2%
Snug Harbor	9.570	3.715	-61.2%
Mashapaquit Creek	17.649	6.844	-61.2%

Target nitrogen removal for West Falmouth Harbor System: (41.739 kg/day – 18.529 kg/day) = 23.21 kg/day x 365 days/yr = ~ 8472 kg/year

Discussion of Decision Support Tool Evaluation

Figure 3 is a summary map that does not show suitable areas for shellfish aquaculture. Because West Falmouth is a busy boat basin, there is lack of space and use conflicts are ranked high. This area is also fully utilized for the Town's highly successful program for municipal propagation of quahogs and oysters by bottom planting (no gear required). For these threshold considerations, aquaculture leases are not recommended in this harbor.

Quissett Harbor

Figure 4 shows eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked.

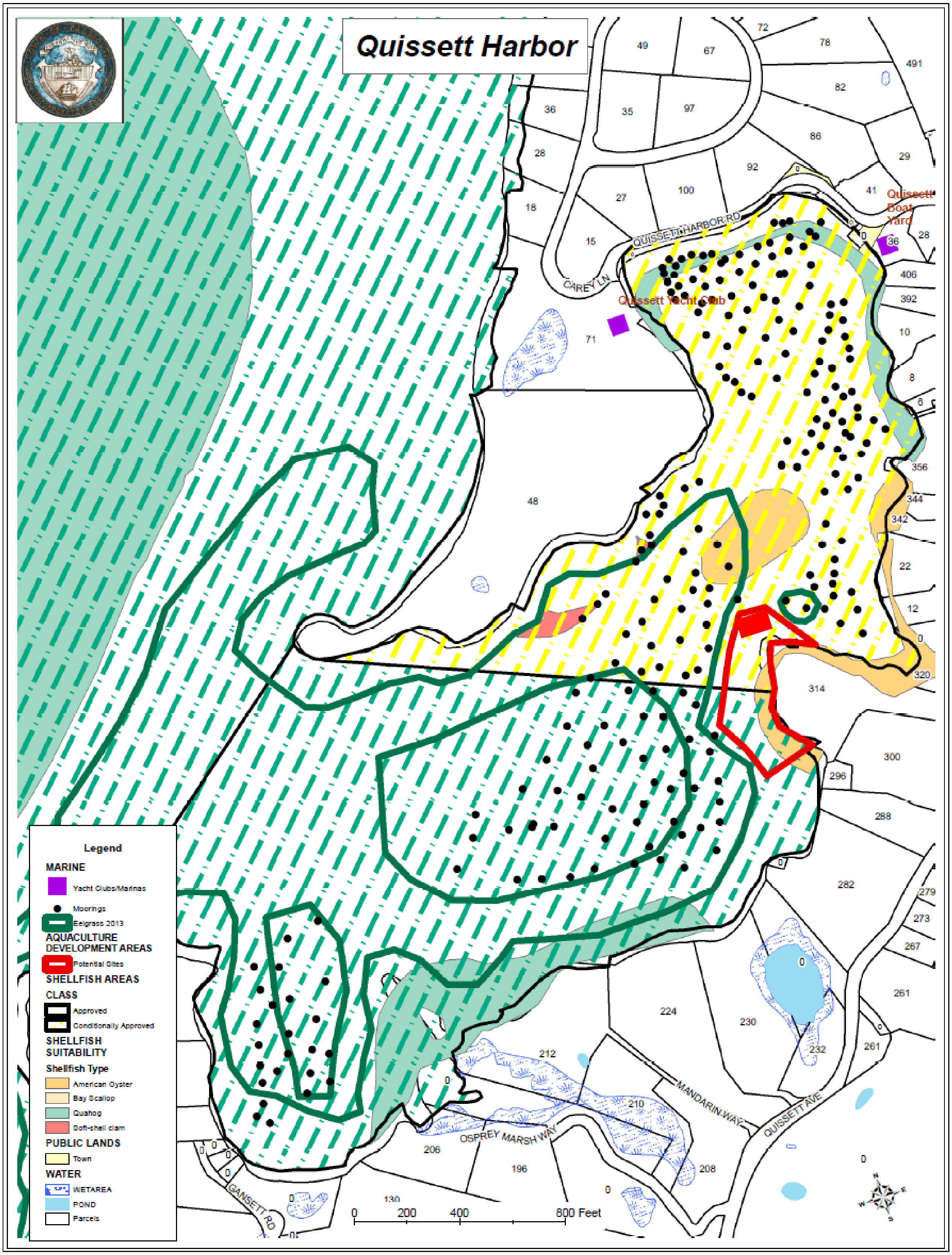


Figure 4. Quissett Harbor: Map of Habitat, Infrastructure, Public Uses and Potential Aquaculture Areas

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for Quissett Harbor include:

Eelgrass and Sediment Type

As shown in Figure 4, eelgrass beds are found throughout outer Quissett Harbor. There is not a historic record of eelgrass in the inner harbor. The main loss of eelgrass is documented for the transition area between the outer to the inner harbor. Sediment in the main basin of the inner harbor is fine grained and rich in organic matter (muck). The outer harbor and areas closer to shore have a more hard, sandy bottom.

Shellfish/finfish

As shown in Figure 4, DMF Shellfish Growing Area maps classify inner Quissett Harbor as conditionally approved and outer Quissett Harbor as approved. These areas have active oyster drill populations and are considered suitable habitat for quahogs, soft-shelled clams and oysters. Commercial and recreational wild harvest of quahogs, soft-shelled clams and oysters occurs in both inner and outer Quissett Harbor.

Infrastructure/Public Uses

Quissett Harbor is a multi-use recreation area. As shown in Figure 4, there is a town dock and private boatyard off Quissett Harbor Road, and a beach managed by Quissett Land Trust and Salt Pond Area Bird Sanctuaries with a very small parking lot at the end of Quissett Harbor Road. Quissett Yacht Club is also located at the end of Quissett Harbor Road. There are 103 boatyard/yacht club moorings and 133 private moorings in Quissett Harbor. Private moorings are administered through the town. This recreation area is heavily used in the summer for boating, sailing lessons, and swimming.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for the Quissett Harbor System. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in both the inner and outer harbor (between 2 ug/L and 21 ug/L). In Quissett Harbor, data loggers were installed at two monitoring stations over a 24-day period in July. These two locations have comparable patterns of Chl-*a* availability, with average concentrations of 10.6 ug/L reported in the inner harbor and 6.5 ug/L in the outer harbor. Chl-*a* levels fall below 5 ug/L 9% of the deployment period in the inner harbor and 36% of the deployment period in the outer harbor. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

According to the MEP Report, bottom water dissolved oxygen concentrations do not typically decline below 4 mg/L in either the inner or outer harbor. This indicates that oxygen should not be a limiting factor in shellfish propagation.

Table 6. Executive Summary Table from MEP Report for Quissett Harbor

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Quissett Harbor estuary system, Town of Quissett, Massachusetts.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
SYSTEMS						
Quissett Harbor (Main)	1.458	1.458	0.928	-3.159	-0.773	0.0%
Quissett Harbor (Upper)	1.921	1.192	0.409	3.840	5.441	-38.0%
System Total	**3.379**	**2.650**	**1.337**	**0.681**	**4.668**	**-21.6%**

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Quissett Harbor (main): 0 kg/day
Quissett Harbor (upper): (1.921 kg/day – 1.192 kg/day) = 0.729kg/day x 365 days/yr = ~ 266 kg/year
Target nitrogen removal for Quissett Harbor system: (3.379 kg/day – 2.65 kg/day) =.729 kg/day/ ~ 266 kg/year

Based on Table 6, approximately 266 kg N per year must be removed for Quissett Harbor to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figure 4 is a summary map that shows a potentially suitable area for shellfish aquaculture, including:

- Area off the National Academy of Sciences property (approximately 3 acres)

These specific areas within the overall Quissett Harbor estuarine system are considered appropriate for private aquaculture based on the six Overriding/Threshold Consideration criteria. In summary: these locations are not within an area prohibited to shellfishing; these sites do not impinge on eelgrass, moorings and navigation channels; aesthetic concerns are not ranked high; use conflicts are not ranked high; municipal propagation of oysters does not occur in these areas; and it is likely that shellfish could be successfully cultivated at these locations. Key implementation considerations include: shellfish cannot be grown to harvestable size within the inner harbor; some sections of this estuary are used for wild commercial harvest so a survey for productive bottom is needed; the closure period within which private aquaculture could occur is moderate (between July 1 and September 30; public access for boat launching is not nearby and there is no public landing, but a skiff might be able to be kept on the Town dock; and the value of shellfish cultivation for nitrogen-removal is high.

Falmouth Harbor/Little Pond

These estuaries are included in the Rotational Aquaculture Plan because they are key nursery areas for the town's shellfish propagation program. ADAs are not recommended in Falmouth Harbor or Little Pond.

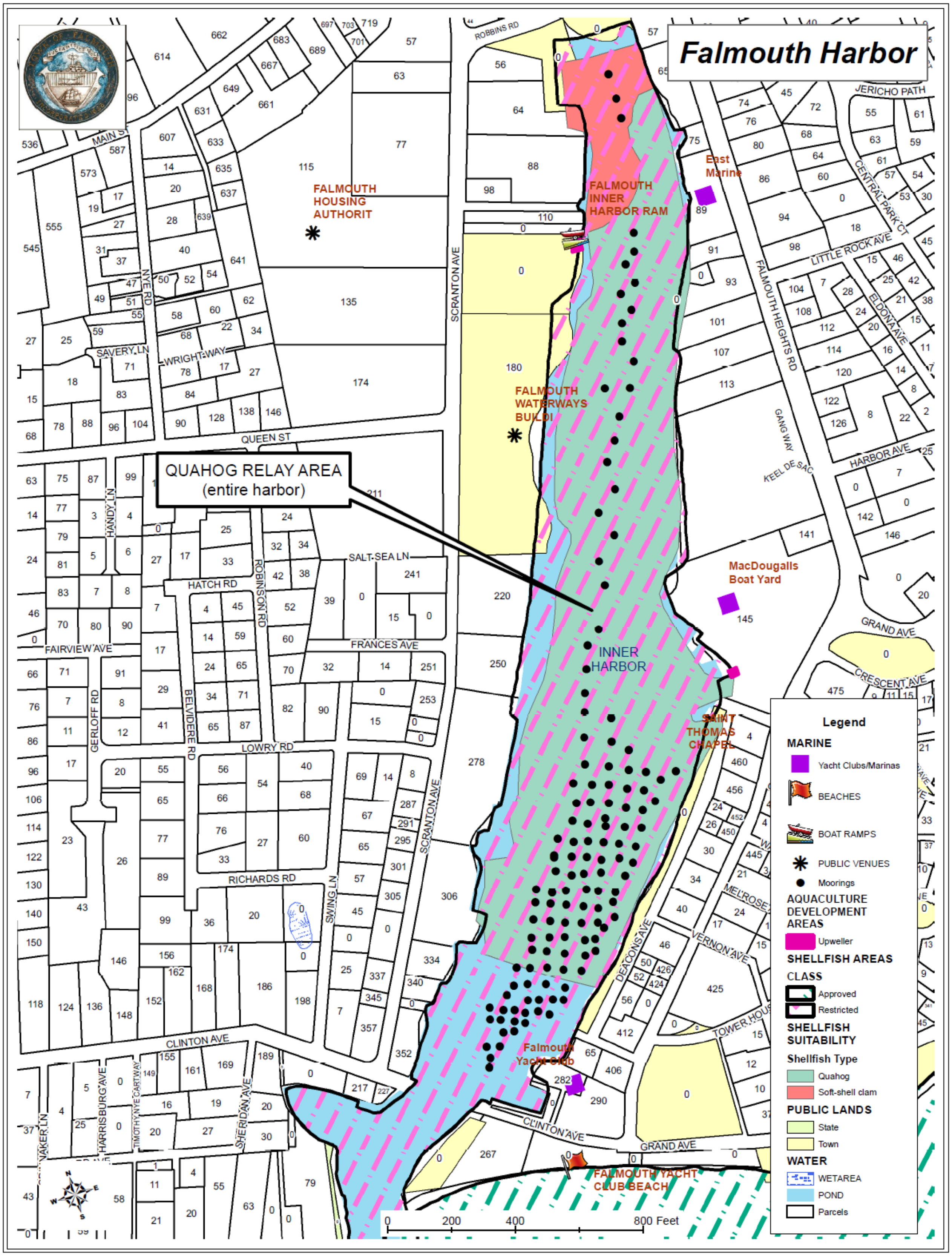


Figure 5. Falmouth Harbor: Map of Habitat, Infrastructure and Public Uses

Eelgrass and Sediment Type

As shown in Figure 5, Falmouth Harbor has never contained eelgrass habitat because it is a manmade system formed by the opening of a fresh pond in 1907 to create a protected harbor for boats. As shown in Figure 6, Little Pond has a patch of eelgrass in the middle of the lower basin, near the inlet opening.

Shellfish/finfish

As shown in Figures 5 and 6, DMF Shellfish Growing Area maps classify Falmouth Harbor as restricted and Little Pond as prohibited. Falmouth Harbor is considered suitable habitat for quahogs and soft-shelled clams and Little Pond is considered suitable habitat for soft-shelled clams. Commercial and recreational wild harvest of quahogs, soft-shelled clams and oysters does not occur in either Falmouth Harbor or Little Pond.

Infrastructure/Public Uses

Falmouth Harbor is a multi-use recreation area. As shown in Figure 5, there is a town marina and public boat ramp as well as two private marinas and a yacht club. There are 36 boatyard/yacht club moorings and 75 private moorings in Falmouth Harbor. Private moorings are administered through the town. This recreation area is heavily used in the summer for boating, sailing lessons, and swimming. The town operates a shellfish propagation center at Falmouth Harbor with five large upwellers. There is an additional Town upweller at MacDougall's Boatyard.

There is one pubic access point into Little Pond, at Spring Bars Road. Internal combustion engines are not allowed in Little Pond but paddlers enjoy this waterbody. The town operates a shellfish farm in Little Pond at the end of Brockton Street. These oysters are only grown in Little Pond until they reach 2-inches and then are bottom-planted in other estuaries for recreational and commercial harvest after a depuration period.

Water Quality

The MEP Report for the Falmouth Harbor and Little Pond Systems present goals for the nitrogen-removal required to restore water quality and ecosystems health.

Table 7. Executive Summary Table from MEP Report for Falmouth Inner Harbor

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Falmouth Harbor estuary system, Town of Falmouth, Massachusetts.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
SYSTEMS						
Upper Harbor	2.573	1.888	0.219	0.629	2.736	-26.6%
Lower Harbor	3.860	2.832	0.219	0.632	3.683	-26.6%
Morse Culvert	0.764	0.764	--	--	0.764	0.0%
System Total	**7.197**	**5.484**	**0.438**	**1.261**	**7.183**	**-23.8%**

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentration identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Falmouth Harbor: (7.197 kg/day – 5.484 kg/day) = 1.713 kg/day x 365 days/yr = ~ 625 kg/year
Target nitrogen removal for Falmouth Harbor: ~600 kg N/year

Table 8. Load Summary Table from MEP Report for Little Pond

Table VIII-3. Comparison of sub-embayment ***total attenuated watershed loads*** (including septic, runoff, and fertilizer) used for modeling of present and threshold loading scenarios of the Little Pond system. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	threshold load (kg/day)	threshold % change
Little Pond	13.022	2.603	-80.0%
Surface Water Sources			
Little Pond Stream	6.052	2.755	-54.5%

Little Pond: (13.022 kg/day – 2.603 kg/day) = 10.419 kg/day x 365 days/yr = ~ 3,800 kg/year
Little Pond Stream: (6.052 kg/day – 2.755 kg/day) = 3.297 kg/day x 365 days/yr = ~ 1,200 kg/year
Target nitrogen removal for Little Pond: ~5,000 kg N/year

Based on Tables 7 and 8, approximately 600 kg N and 5,000 kg N per year must be removed for Falmouth Harbor and Little Pond (respectively) to meet the regulatory standard for TN. The Little Pond sewer project removes all the septic nitrogen from the lower watershed and part of the septic nitrogen from the upper watershed. Sewering of the lower watershed removes 80% of the nitrogen load (MEP pg 117). Sewering of the lower watershed and part of the upper watershed, combined with fertilizer reductions, removes approximately 88% of the nitrogen load. The remaining load to be removed is 600 kg N/year.

Discussion of Decision Support Tool Evaluation

Figures 5 and 6 do not show any suitable areas for shellfish aquaculture. Falmouth Harbor is restricted to shellfishing, supports six town upwellers, is a busy boat basin with lack of space, and use conflicts are ranked high. Little Pond is closed to shellfishing, has limited public access and supports an oyster nursery for municipal propagation. For these reasons, private aquaculture sites are not recommended within these two waterbodies.

<u>Great Pond</u>

Figures 6 and 7 show eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked.

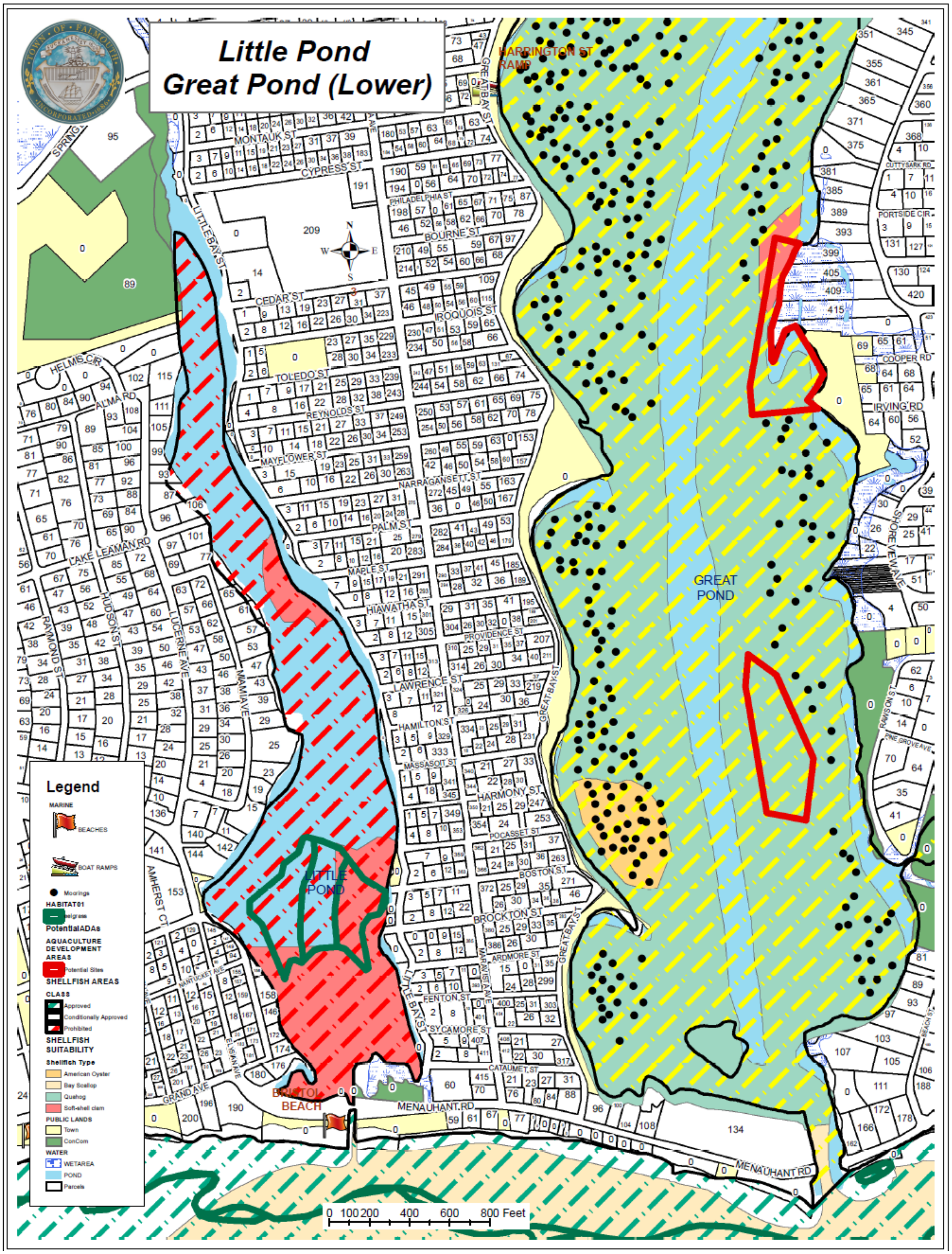


Figure 6. Little Pond and Lower Great Pond: Map of Habitat, Infrastructure, Public Uses and Potential Aquaculture Areas

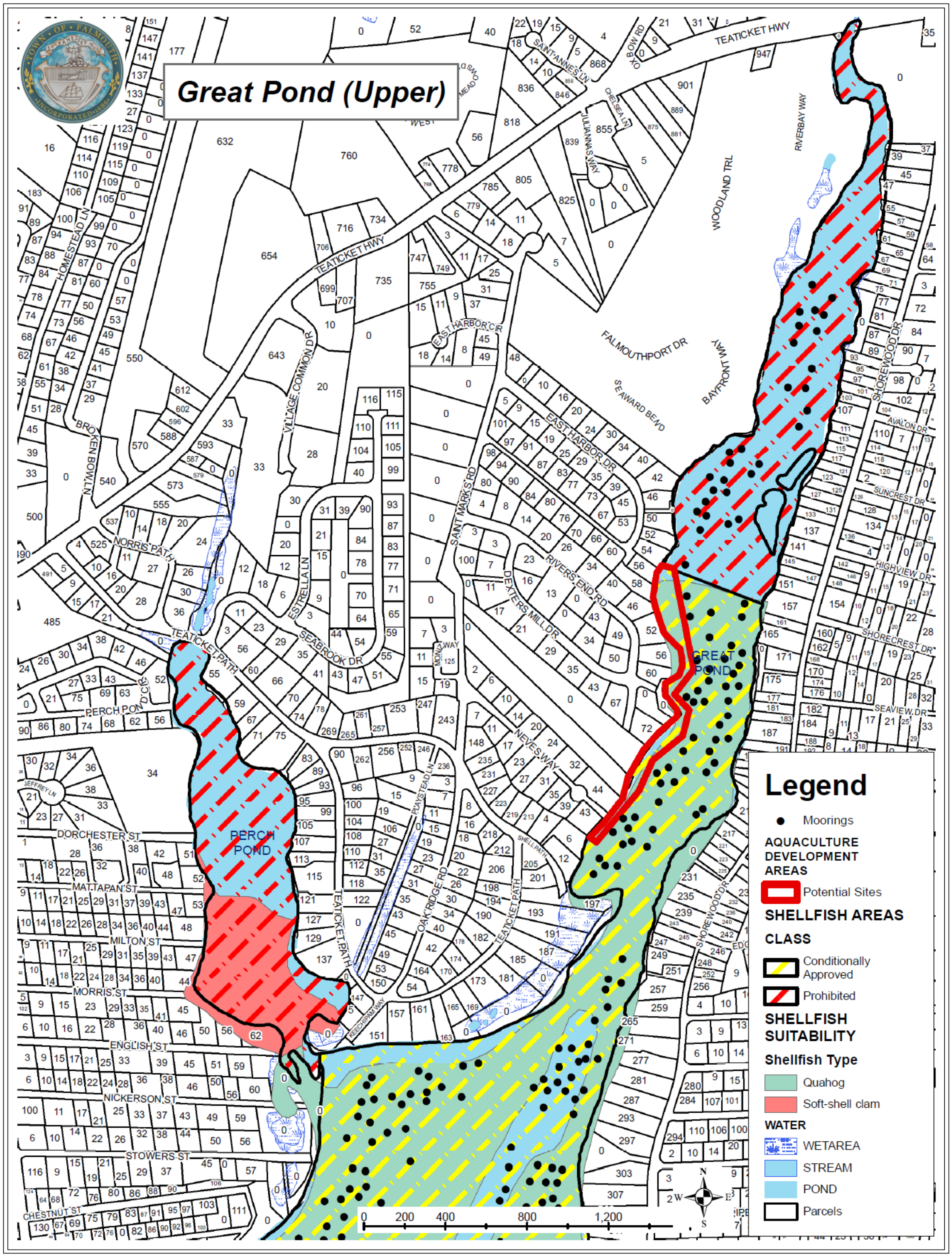


Figure 7. Upper Great Pond: Map of Habitat, Infrastructure, Public Uses and Potential Aquaculture Areas

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for Great Pond include:

Eelgrass and Sediment Type

As shown in Figures 6 and 7, currently, there is a small amount of eelgrass in Great Pond, mainly along the shore. Historically, a bed of eelgrass was found near the inlet. Sediment is predominantly fine grained and rich in organic matter (muck), with some sandy areas near the town boat landing.

Shellfish/finfish

As shown in Figures 6 and 7, DMF Shellfish Growing Area maps classify Great Pond as conditionally approved except for the area north of East Harbor Drive as well as Perch Pond which are classified as prohibited. Great Pond is considered suitable habitat for quahogs and soft-shelled clams. Commercial and recreational wild harvest of quahogs occurs in several areas within Great Pond.

Infrastructure/Public Uses

Great Pond is a multi-use recreation area. As shown in Figure 6, there is a town dock and boat ramp located off Harrington Street, with a small parking lot. This recreation area is heavily used in the summer for boating, town-run sailing lessons, and swimming.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for the Great Pond System. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in Great Pond (between 1 ug/L and 70 ug/L). Data loggers were installed at two monitoring stations over a 27-day period in July. These two locations have comparable patterns of Chl-*a* availability, with average concentrations not reported. Chl-*a* levels do not fall below 5 ug/L during any of the deployment period in the upper pond and 22% of the deployment period in the lower pond. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

According to the MEP Report, bottom water dissolved oxygen concentrations are less than 3 mg/L in the upper pond 29% of the deployment period and less than 3 mg/L for 17% of the time in the lower pond, indicating a periodic anoxic bottom-water environment. These findings should be verified using updated data.

Table 9. Load Summary Table from MEP Report for Great, Green and Bournes Pond

Table VIII-3. Comparison of sub-embayment ***total attenuated watershed loads*** (including septic, runoff, and fertilizer) used for modeling of present and threshold loading scenarios of the Ashumet Valley systems. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	threshold load (kg/day)	threshold % change
Great Pond	25.00	3.72	-85.1%
Perch Pond	5.38	0.90	-83.2%
Green Pond	18.55	6.35	-65.8%
Bournes Pond	9.61	1.31	-86.4%
Israels Cove	2.05	0.27	-86.8%
Surface Water Sources			
Coonamessett River (Great Pond)	22.63	15.09	-33.3%
Backus Brook (Green Pond)	3.81	3.81	0.0%
Bournes Brook (Bournes Pond)	3.29	1.97	-40.3%

Great Pond (main): (25 kg/day – 3.72 kg/day) = 21.28 kg/day x 365 d/y = 7767 kg/yr
Perch Pond: (5.38 kg/day – 0.9 kg/day) = 0.4.48 kg/day x 365 d/y = 1635 kg/yr
Coonamessett River (22.63 kg/day – 15.09 kg/day) = 7.54 kg/d x 365 d/y = 2752 kg/yr
Target nitrogen removal for Great Pond system: ~12,000 kg N/year

Based on Table 9, approximately 12,000 kg N per year must be removed for Great Pond to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figures 6 and 7 are summary maps that shows potentially suitable areas for shellfish aquaculture, including:

- Along the eastern shore of upper Great Pond (~1.0 acres)
- Along the western shore of upper Great Pond (~2.5 acres)
- Off the western shore of lower Great Pond near Cooper Road (~3.5 acres)
- Off the western shore of lower Great Pond near Ramon Street (~3.5 acres)

These specific areas within the overall Great Pond estuarine system are considered appropriate for private aquaculture based on the six Overriding/Threshold Consideration criteria. In summary: these locations are not within a prohibited area; these sites do not impinge on eelgrass, moorings and navigation channels; aesthetic concerns are not ranked high; use conflicts are not ranked high; municipal propagation of oysters does not occur in this area; and it is likely that shellfish could be successfully cultivated at this location. Key implementation considerations include: shellfish cannot be grown to harvestable size; sections are heavily used for wild commercial harvest so a survey for productive bottom is needed; the closure period within which private aquaculture could occur is moderate (between May 1 and October 31); public access for boat launching is nearby and there is a public boat landing at Harrington Street; and the value of shellfish cultivation for nitrogen-removal is high.

The seed that is cultivated in these conditional areas must be moved to open grow-out areas after the first growing period that is determined by the closure period for wild harvesting. These final grow-out areas may either be within existing offshore grants, or be in new licensed sites in Vineyard Sound that will be identified as part of the permitting process.

Green Pond

Figures 8 and 9 show eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked.

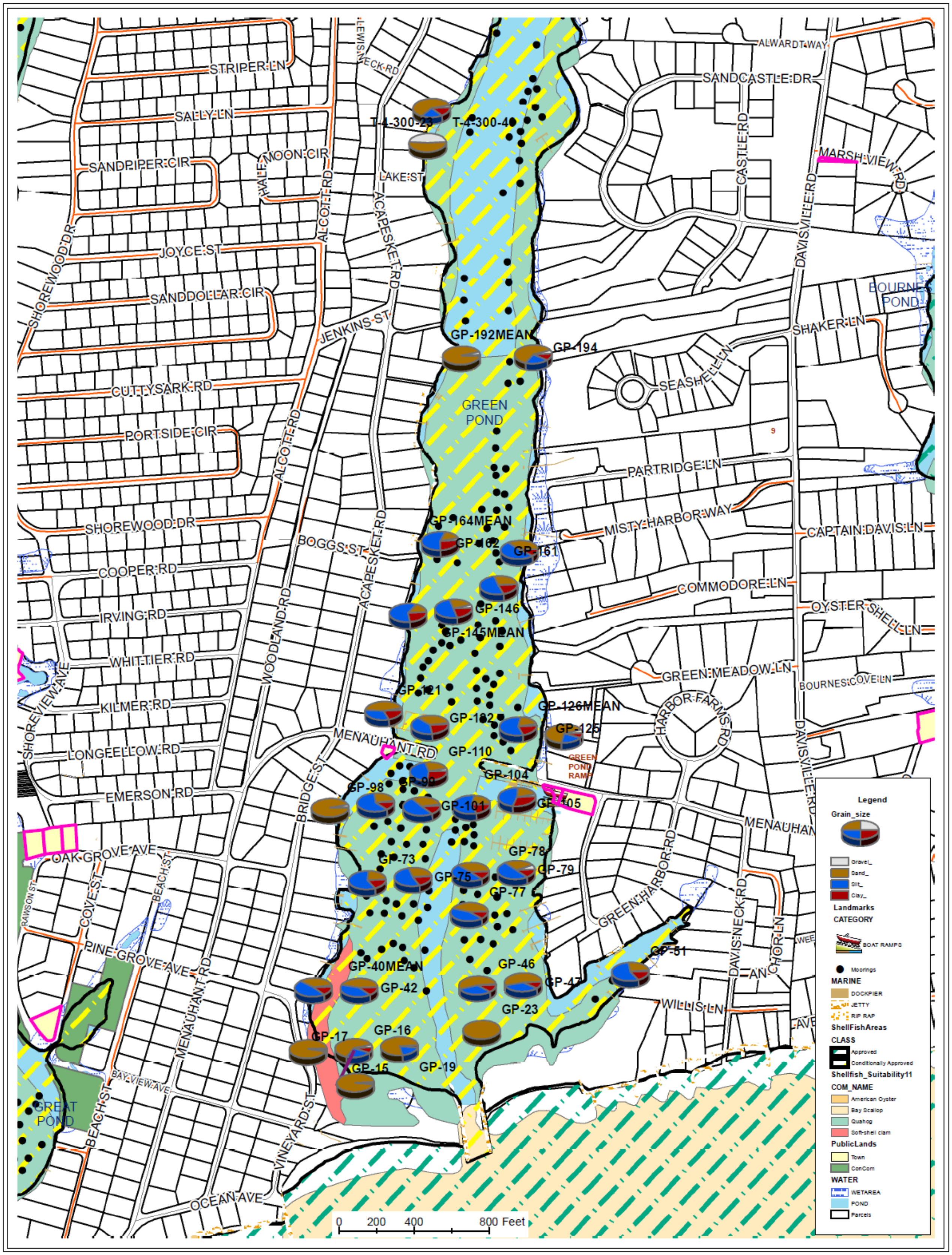


Figure 8. Lower Green Pond: Map of Habitat, Infrastructure and Public Uses

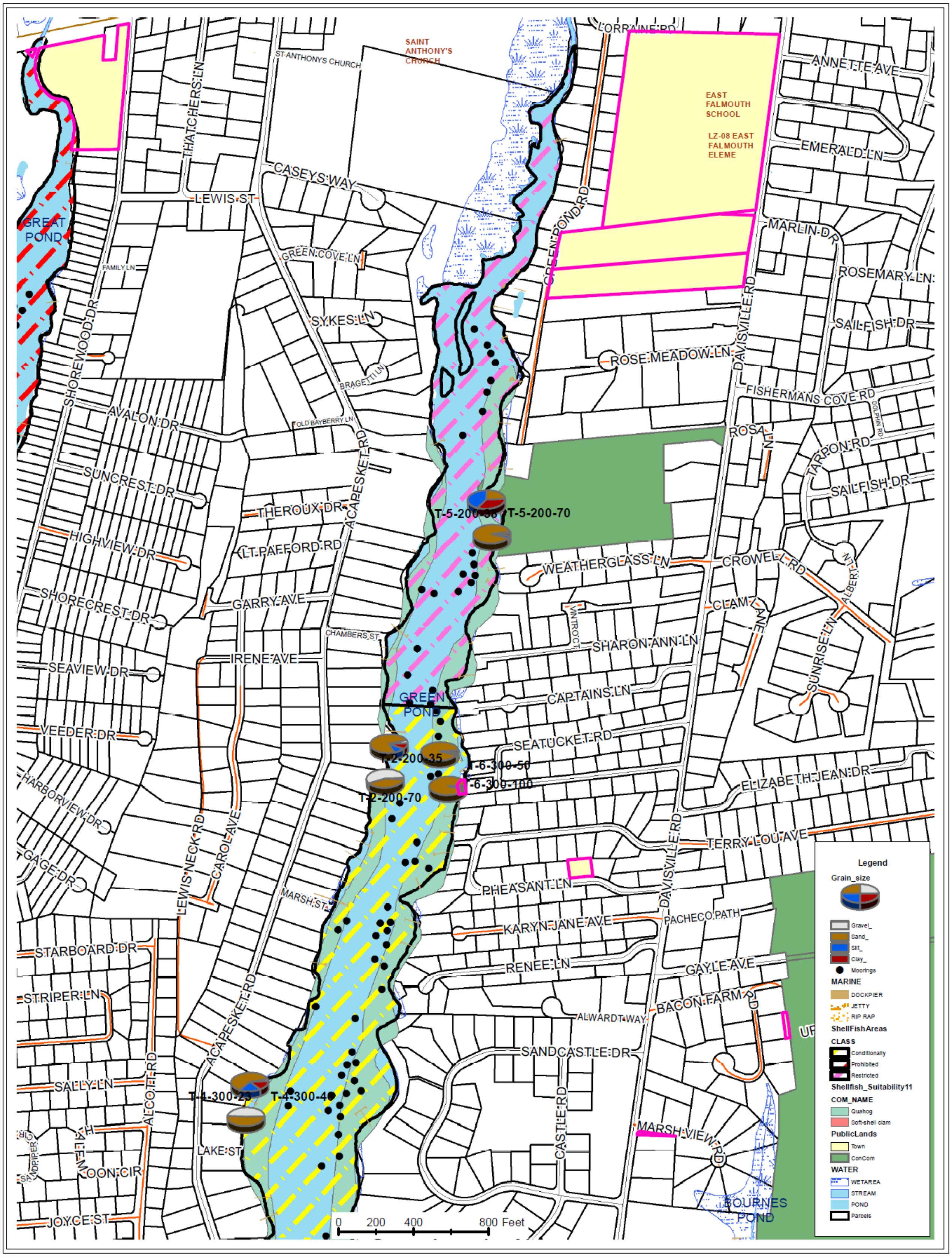


Figure 9. Upper Green Pond: Habitat, Infrastructure and Public Uses Map

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for Green Pond include:

Eelgrass and Sediment Type:

As shown in Figures 8 and 9, currently, there is no eelgrass in Green Pond although historically eelgrass grew throughout the pond south of route 28. Additional information on eelgrass and sediment types is available from the detailed habitat assessments that were conducted as part of preparing the draft Green Pond Harbor Management Plan (GPHMP). The environmental assessment completed for the Draft Green Pond Harbor Management Plan included physical, chemical and biological data as follows:

- Depth (bathymetry)
- Sediment grain size
- Total organic carbon (TOC)
- Apparent redox potential discontinuity (aRPD) layer depth
- Invertebrate indicator species abundance and distribution
- Shellfish abundance (high, medium and low)
- Presence/absence of eelgrass

Data for shellfish abundance, aRPD and eelgrass was collected at 158 stations, grain size and TOC data were taken at 40 stations and benthic indicator species data were obtained at 10 stations. To establish data collection sites, Green pond was divided into upper habitat and lower habitat using the demarcation on the Massachusetts GIS website where MA DEP designated the lower pond (south of Jenkins Street) as suitable habitat for quahogs as well as soft-shell clams, while designating only the shoreward edges of the upper reaches (north of Jenkins Street) as suitable for soft-shell clams. Prior to the start of field efforts, the lower pond was gridded on a paper map into north/south and east/west transects spaced 100 feet apart. Each intersection was assigned a number (GP1 – GP204) and was considered a potential sampling station. Of the 204 potential sampling sites, 80 were randomly selected and 20 specifically chosen (for larger areas missed by random selection) for analysis of shellfish and eelgrass presence or absence (100 stations). The upper reaches were sampled at 100 foot intervals along 500 foot long transects. The transects ran parallel to the shore, at a distance of 100 feet from mean high water if possible. In addition, each transect included one “shore normal” transect which ran perpendicular to the shore, with sampling stations at the intertidal area as well as the mid-point of one transect station (e.g. Transect 1 at the 300-foot station was sampled at 50 feet from shore, 25-feet from shore, and at the intertidal area). A total of seven (7) transects with eight (8) stations each were sampled for shellfish in the upper reaches (56 stations). Additionally, to field-verify the transition between the upper and lower reaches portrayed by MA DEP, a central rake haul transect was sampled.

At each station in the lower pond where eelgrass may have been present, an underwater investigation of the area was performed using a view box. No eelgrass was present. At each station sampled for shellfish, sediment was collected for the analysis of grain-size and total organic carbon (TOC). From the 156 stations, forty stations along cross-pond transects were selected to have the sediment samples analyzed for grain-size and TOC, with five duplicate samples run for QA/QC purposes (total of 45 samples). Ten sites were selected randomly from the shellfish stations for analysis of a 0.04 m2 Van Veen benthic grab for the presence or absence of species indicative of poor or stressed habitat.

The GIS layer that was developed to summarize the results of this data collection effort is included in Figure 6. The draft GPHMP concludes that north of the Green Pond bridge is unlikely to be a suitable habitat for eelgrass, even when water quality has improved. South of the bridge, eelgrass recolonization is expected to be slow. Most of the sediment is fine grained and rich in organic matter (muck), with some sandy areas near the pond inlet and along the Green Pond bridge where the town currently relays oysters as part of its municipal propagation program.

Shellfish/Finfish:

As shown in Figures 8 and 9, DMF Shellfish Growing Area maps classify Green Pond as conditionally approved except for the area north of Rose Meadow Lane which is prohibited. Green Pond is considered suitable habitat for quahogs and soft-shelled clams. Commercial and recreational wild harvest of quahogs and oysters occurs in several areas within Green Pond.

According to the draft GPHMP, the highest value shellfish habitat is currently located south of the bridge, and moderate value shellfish habitat is near the shoreline throughout much of the pond. The central areas of the pond and the extreme northern end of the pond are considered low value shellfish habitat (Figure 9). Alewife run into Mill Pond from Green Pond.

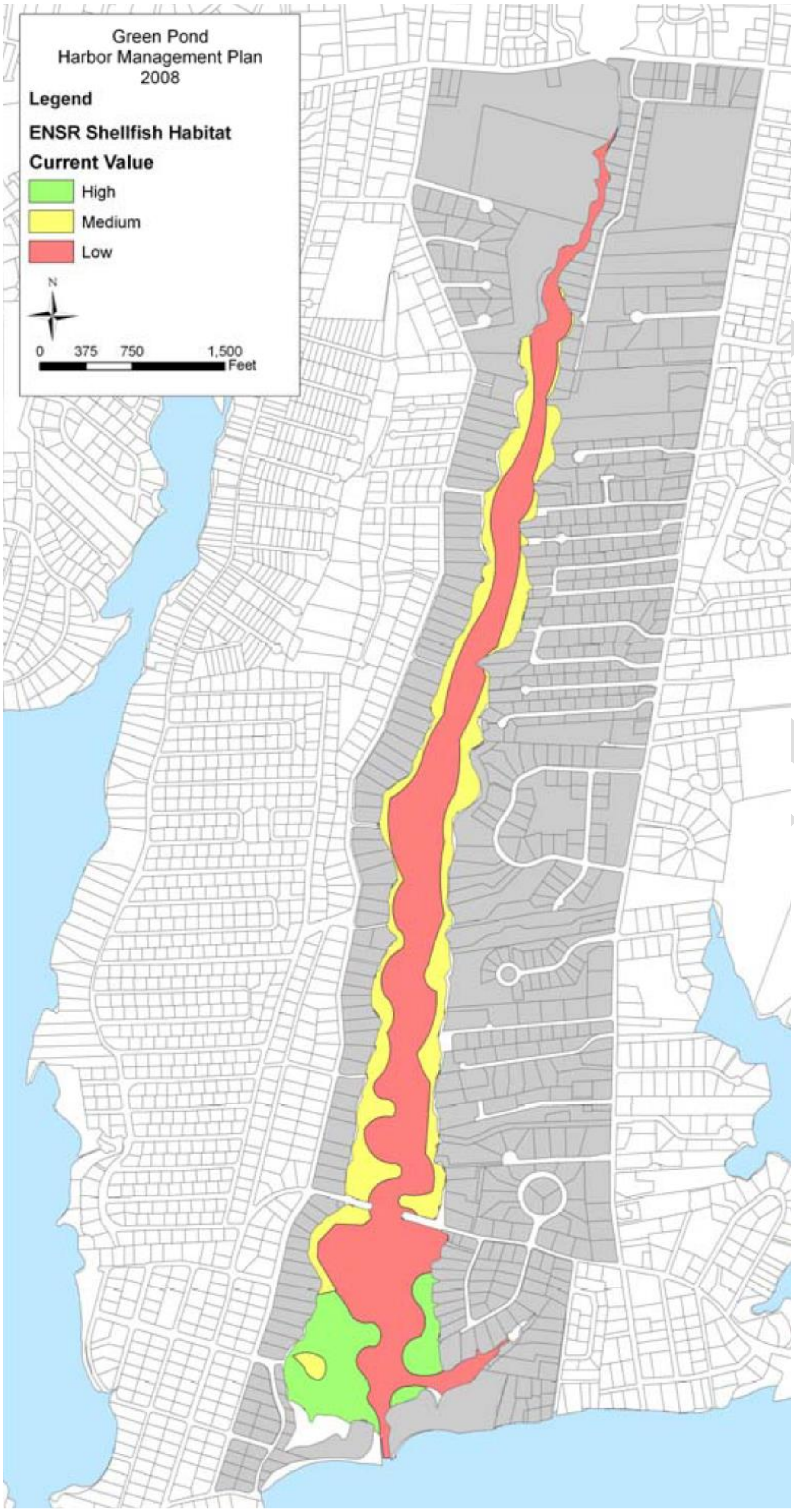


Figure 10. Relative value of shellfish habitat in Green Pond

Infrastructure/Public Uses

Great Pond is a multi-use recreation area. As shown in Figure 8, there is a town dock and boat ramp, and a parking lot with spaces for 19 vehicles with boat trailers and two vehicle spaces as well as a private marina. There are 328 private moorings in Great Pond. Private moorings are administered through the town. This recreation area is heavily used in the summer for boating, and swimming. The Department of Marine and Environment maintains an upweller at the boat landing.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for the Green Pond System. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in Green Pond (between 10 ug/L and 120 ug/L, with values at 5 ug/L close to the inlet). Data loggers were installed at three monitoring stations over an approximately 27-day period in July and August. These three locations have comparable patterns of Chl-*a* availability, with average concentrations not reported. Chl-*a* levels did not fall below 5 ug/L during any of the deployment period anywhere in the pond. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

According to the MEP Report, bottom water dissolved oxygen concentrations are seldom less than 4 mg/L in Green Pond. This indicates that oxygen should not be a limiting factor in shellfish propagation. These findings should be verified using updated data.

Table 10. Load Summary Table from MEP Report for Great, Green and Bournes Pond

Table VIII-3. Comparison of sub-embayment ***total attenuated watershed loads*** (including septic, runoff, and fertilizer) used for modeling of present and threshold loading scenarios of the Ashumet Valley systems. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	threshold load (kg/day)	threshold % change
Great Pond	25.00	3.72	-85.1%
Perch Pond	5.38	0.90	-83.2%
Green Pond	18.55	6.35	-65.8%
Bournes Pond	9.61	1.31	-86.4%
Israels Cove	2.05	0.27	-86.8%
Surface Water Sources			
Coonamessett River (Great Pond)	22.63	15.09	-33.3%
Backus Brook (Green Pond)	3.81	3.81	0.0%
Bournes Brook (Bournes Pond)	3.29	1.97	-40.3%

Green Pond (main): (18.55 kg/day – 6.35 kg/day) = 12.2 kg/day x 365 d/y = 4453 kg/yr
Backus Brook: 0 kg/day
Target nitrogen removal for Green Pond system: ~4500 kg N/year

Based on Table 10, approximately 4,500 kg N per year must be removed for Green Pond to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figures 8 and 9 are summary maps that do not show suitable areas for shellfish aquaculture. Because Green Pond is a busy boat basin, there is lack of space, and use conflicts are ranked high. This is also a highly successful area for municipal propagation of quahogs and oysters by bottom planting (no gear required). For these reasons, private aquaculture sites are not recommended for this harbor.

Bournes Pond

Figure 11 shows eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked.

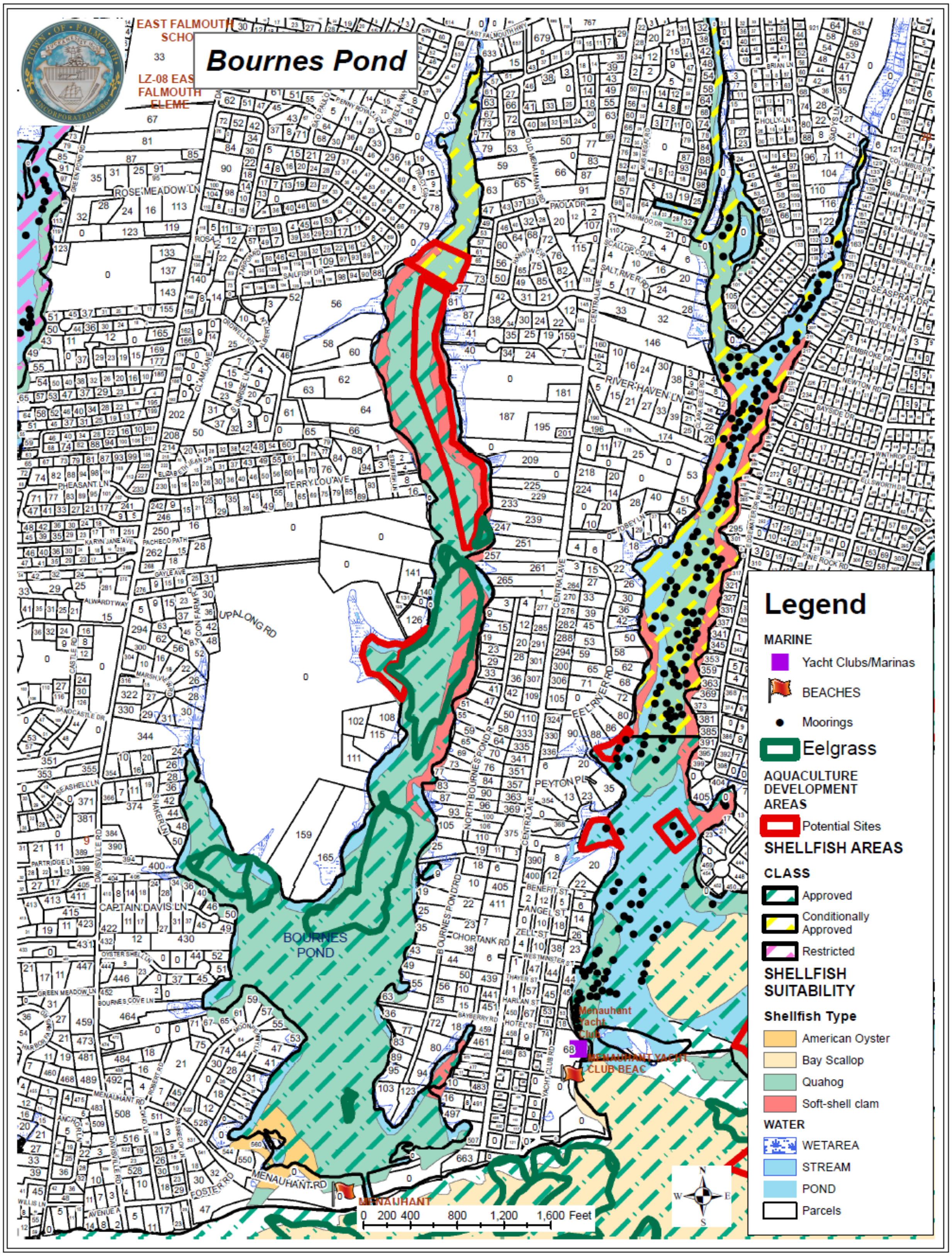


Figure 11. Bournes Pond: Map of Habitat, Infrastructure, Public Uses and Potential Aquaculture Areas

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for Bournes Pond include:

Eelgrass and Sediment Type

As shown in Figure 11, currently, there are eelgrass beds along the shore throughout the middle section of Bournes Pond. Sediment is predominantly fine grained and rich in organic matter (muck), with some sandy areas in the center of the middle section of the pond.

Shellfish/finfish

As shown in Figure 11, DMF Shellfish Growing Area maps classify Bournes Pond as approved except for the area north of Sailfish Drive which is conditionally approved. Bournes Pond is considered suitable habitat for quahogs and soft-shelled clams. Commercial and recreational wild harvest of quahogs and soft-shelled clams occurs in several areas within Bournes Pond.

Infrastructure/Public Uses

Boat access to Bournes Pond is limited by the height of the bridge over the inlet. As shown in Figure 11, off Pacheco Path, there is a parking area and a path for public access to the water, but there is no boat ramp. There are 16 private moorings in Bournes Pond. Private moorings are administered through the town.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for the Bournes Pond System. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in Green Pond (between 5 ug/L and 55 ug/L). Data loggers were installed at two monitoring stations over an 27-day period in July and August. Data for one logger is presented, with average concentrations not reported. Chl-*a* levels fell below 5 ug/L a de minims 1% of the deployment period. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

According to the MEP Report, bottom water dissolved oxygen concentrations are less than 3 mg/L in the upper pond 34% of the deployment period and less than 3 mg/L for 4% of the time in the lower pond, indicating a periodic anoxic bottom-water environment. These findings should be verified using updated data.

Table 11. Executive Summary Table from MEP Report for Bournes Pond

Table VIII-3. Comparison of sub-embayment ***total attenuated watershed loads*** (including septic, runoff, and fertilizer) used for modeling of present and threshold loading scenarios of the Ashumet Valley systems. These loads do not include direct atmospheric deposition (onto the sub-embayment surface) or benthic flux loading terms.

sub-embayment	present load (kg/day)	threshold load (kg/day)	threshold % change
Great Pond	25.00	3.72	-85.1%
Perch Pond	5.38	0.90	-83.2%
Green Pond	18.55	6.35	-65.8%
Bournes Pond	9.61	1.31	-86.4%
Israels Cove	2.05	0.27	-86.8%
Surface Water Sources			
Coonamessett River (Great Pond)	22.63	15.09	-33.3%
Backus Brook (Green Pond)	3.81	3.81	0.0%
Bournes Brook (Bournes Pond)	3.29	1.97	-40.3%

Bournes Pond (main): (9.61 kg/day – 1.31 kg/day) = 8.3 kg/day x 365 d/y = 3030 kg/yr
Israels Cove: (2.05 kg/day – 0.27 kg/day) = 1.78 kg/d x 365 d/y = 650 kg/yr
Bournes Brook: (3.29 kg/day – 1.97 kg/day) = 1.31 kg/d x 365 d/y = 482 kg/yr
Target nitrogen removal for Bournes Pond system: ~ 4000 kg N/year

Based on Table 11, approximately 4,000 kg N per year must be removed for Bournes Pond to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figure 11 is a summary map that shows potentially suitable areas for shellfish aquaculture, including:

- Within the conditionally-approved area (~2.5 acres)
- 50-feet off the eastern shore (~11 acres)
- Off the western shore of Sea Farms (2.5 acres)

The sand flat located near Pacheco Path is part of the Town's municipal propagation program and should not be included in the ADA.

These specific areas within the overall Bournes Pond estuarine system are considered appropriate for private aquaculture based on the six Overriding/Threshold Consideration criteria. In summary: these locations are not within an area prohibited to shellfishing; these sites do not impinge on eelgrass, moorings and navigation channels; aesthetic concerns are not ranked high; use conflicts are not ranked high; municipal propagation of oysters does not occur in these specific areas; and it is likely that shellfish could be successfully cultivated at these locations. Key implementation considerations include: shellfish can be grown to harvestable size; some sections of this estuary are used heavily for wild commercial harvest so a survey for productive bottom is needed; there is no closure period; public access for boat launching is minimal, there is no public boat landing into this estuary and the height of the bridge at the inlet limits boat size to small skiffs; and the value of shellfish cultivation for nitrogen-removal is high.

Waquoit Bay including Eel Pond

Waquoit Bay is a designated Area of Critical Environmental Concern (ACEC). Figure 12 shows eelgrass beds, DMF classifications of shellfish growing area and habitat, key infrastructure (such as public landings) and mooring fields. Other unique public use features such as swimming beaches and yacht clubs are also marked.

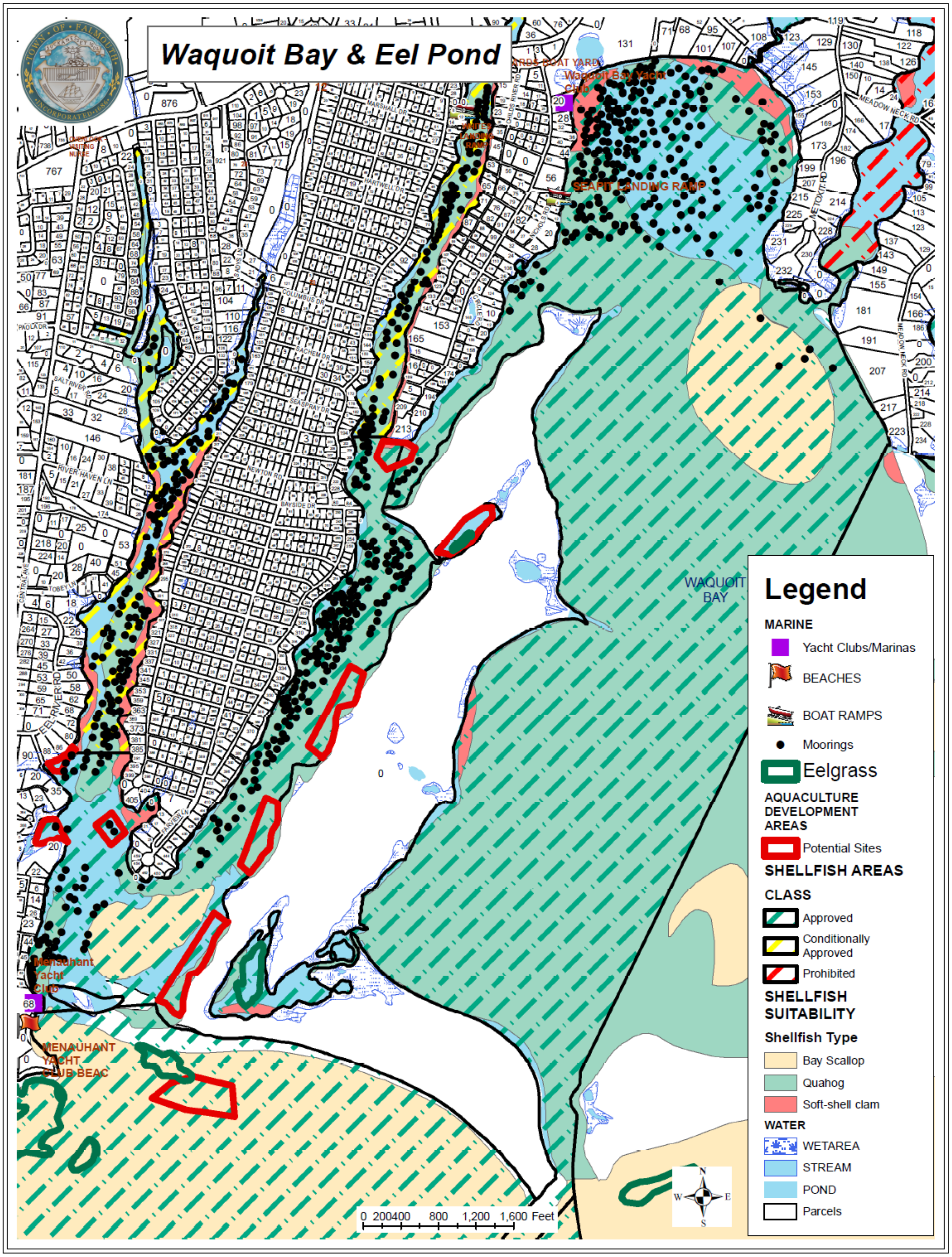


Figure 12. Waquoit Bay and Eel Pond: Map of Habitat, Infrastructure, Public Uses and Potential Aquaculture Areas

Key findings from this habitat and resource mapping, as well as a review of environmental conditions documented in the MEP Report for Waquoit Bay include:

Eelgrass and Sediment Type

As shown in Figures 12, currently, there are no eelgrass beds in Eel Pond or Waquoit Bay with a small patch in Hamblin Pond. Historically Waquoit Bay supported eelgrass in the northern basin with large fringing beds near the inlet. In Eel Pond and the Childs and Seapit River, significant eelgrass existed 60 years ago. There is not a past record of eelgrass in the northern section of the Childs River. Sediment is predominantly fine grained and rich in organic matter (muck), with some sandy areas in the middle section of the bay along the shore. In some areas, the bottom is covered with a mat of macroalgae.

Shellfish/finfish

As shown in Figures 12, DMF Shellfish Growing Area maps classify Waquoit Bay as approved except for the Quashnet/Moonakis River which is prohibited. Eel Pond as approved except for the areas north of Newton Road to the west and Seaspray Drive to the east which are conditionally approved. Eel Pond and Waquoit Bay are considered suitable habitat for quahogs and soft-shelled clams. Commercial and recreational wild harvest of quahogs, soft-shelled clams and scallops (occasionally) occurs in several areas within Eel Pond and Waquoit Bay. Commercial and recreational wild harvest of quahogs and soft-shelled clams occurs in several areas within Waquoit Bay. There is a private aquaculture lease in the Seapit River.

Infrastructure/Public Uses

The Waquoit Bay system is a National Estuarine Research Reserve and a multi-use recreation area. As shown in Figures 12, there are two public boat landings, both located off Route 28. White's Landing accesses the Childs River and is located off White's Landing Road. There is a large dirt parking lot nearby. Waquoit Bay Landing is located on Waquoit Landing Road. There is also a yacht club and a private marina near White's Landing. Washburn Island, a popular camping area, is only accessible by boat.

There are 5 boatyard/yacht club moorings and 221 private moorings in Waquoit Bay 144 private moorings in Eel River (pond) east, 5 yacht club moorings and 169 private moorings in Eel River (pond) west, 12 boatyard moorings and 82 private moorings in the Childs River and 17 private moorings in the Seapit River. Private moorings are administered through the town. This recreation area is heavily used in the summer for boating, sailing lessons and swimming.

Water Quality

Certain water quality parameters including total nitrogen (TN), chlorophyll-*a* (Chl-*a*) and dissolved oxygen (DO) are reported in the MEP Report for the Waquoit Bay System. Chl-*a* concentrations, which are an indicator of phytoplankton food availability varies widely from day to day in the Childs River/Eel Pond system (between 5 ug/L and 55 ug/L). The Waquoit Bay main basin (including data from the upper, mid and lower basin) ranges between 2 ug/L and 14 ug/L, with lower concentrations in the lower basin. Data loggers were installed at three monitoring stations over a period of between 22 and 42 days in July, August and September. These three locations have comparable patterns of Chl-*a* availability, with average concentrations of 15.3 ug/L reported in the upper Bay, 6.8 ug/L mid-Bay and 5.4 ug/L in the lower Bay. Chl-*a* levels were below 5 ug/L, 0%, 11% and 64% of the deployment period, with concentrations declining closer to the inlet. These data are collected 10 cm off the bottom in 15-minute intervals. Surface water Chl-*a* concentrations may be different from bottom water.

In the Childs/Eel Pond system, data loggers were installed at three monitoring stations over a 24-day period in July, August and September. These three locations have varying degrees of of Chl-*a* availability, with average concentrations of 6.2 ug/L reported in Eel Pond near the inlet, 23.3 ug/L in the Childs River and 17.4 ug/L at the "Eel River" station located north of the fork with the Seapit River.

According to the MEP Report, bottom water dissolved oxygen concentrations in both the main basin of Waquoit Bay and the Childs Eel Pond system are seldom less than 5 mg/L, with concentrations lower than 3 mg/L occurring less than 5% of the deployment period. This indicates that oxygen should not be a limiting factor in shellfish propagation.

Table 12. Executive Summary Table from MEP Report for Waquoit Bay System

Table ES-2. Present Watershed Loads, Thresholds Loads, and the percent reductions necessary to achieve the Thresholds Loads for the Waquoit Bay system.

Sub-embayments	Present Watershed Load [1] (kg/day)	Target Threshold Watershed Load [2] (kg/day)	Direct Atmospheric Deposition (kg/day)	Benthic Flux Net [3] (kg/day)	TMDL [4] (kg/day)	Percent watershed reductions needed to achieve threshold load levels
WAQUOIT BAY SYSTEM						
groundwater sources						
Waquoit Bay	2.088	2.088	11.956	-56.779	-42.735	0.0%
Childs River - upper	12.019	4.076	0.455	-4.291	0.240	-66.1%
Eel Pond - east branch	2.170	0.820	1.011	19.480	21.310	-62.2%
Eel Pond - south basin	0.523	0.523	0.663	-4.632	-3.445	0.0%
Eel Pond - west branch	16.337	8.808	0.890	-2.900	6.798	-46.1%
Quashnet River	2.773	1.497	0.252	9.496	11.245	-46.0%
Hamblin Pond	4.381	0.953	1.529	5.712	8.194	-78.2%
Little River	1.096	0.211	0.156	2.554	2.922	-80.7%
Jehu Pond	3.912	1.025	0.674	6.897	8.596	-73.8%
Great River	3.671	0.997	1.307	14.222	16.526	-72.8%
Sage Lot Pond	2.753	1.622	0.471	-2.726	-0.633	-41.1%
surface water sources						
Childs River	10.622	4.115	-	-	4.115	-61.3%
Quashnet River	20.507	13.469	-	-	13.469	-34.3%
Red Brook	8.014	2.096	-	-	2.096	-73.8%
Waquoit Bay System Total	**90.866**	**42.300**	**19.364**	**-12.967**	**48.697**	**-53.4%**

(1) Composed of combined natural background, fertilizer, runoff, and septic system loadings.
(2) Target threshold watershed load is the load from the watershed needed to meet the embayment threshold concentrations identified in Table ES-1.
(3) Projected future flux (present rates reduced approximately proportional to watershed load reductions).
(4) Sum of target threshold watershed load, atmospheric deposition load, and benthic flux load.

Waquoit Bay System:

(90.1 kg/day – 42.3 kg/day) = 47.8 kg/day x 365 d/y = 17,447 kg/yr

From 208 Plan Update Appendix 8C:

- Total Reduction Target = 20,954 kg N/year
- Falmouth share = 11,198 kg N/year (53%)
- Mashpee/Sandwich share = 9,756 kg N/year (42%/5%)

Based on Table 12, approximately 11,200 kg/N per year must be removed *by Falmouth* for Waquoit Bay to meet the regulatory standard for TN.

Discussion of Decision Support Tool Evaluation

Figures 12 is a summary map showing potentially suitable areas for shellfish aquaculture, including:

- Along the western shore of Eel Pond west off Eel River Road (~0.5 acres)
- Along the western shore of Eel Pond west, south of the above site (~1.0 acre)
- Off the eastern side of Seacoast Shores (~1.0 acre)
- Along the western shore of Washburn Island (three sites: ~4.0, 3.0 and 5.0 acres, from north to south)
- With the cove in Washburn Island (~2.5 acres)
- Off the end of Seapit Road (~2.0 acres)
- Offshore, outside the groin at Eel Pond (~5.5 acres)

These specific areas within the overall Waquoit Bay/Eel Pond estuarine system are considered appropriate for private aquaculture based on the six Overriding/Threshold Consideration criteria. In summary: these locations are not within an area prohibited to shellfishing; these sites do not impinge on eelgrass, moorings and navigation channels; aesthetic concerns are not ranked high; use conflicts are not ranked high; municipal propagation of oysters does not occur in these areas; and it is likely that shellfish could be successfully cultivated at these locations. Key implementation considerations include: shellfish can be grown to harvestable size; some sections of this estuary are used heavily for wild commercial harvest so a survey for productive bottom is needed; there is no closure period; public access for boat launching is adequate and there are public boat landings available; and the value of shellfish cultivation for nitrogen-removal is high.

Figure 13 shows the boundary map for the Waquoit Bay National Estuarine Research Reserve (WBNERR) and Area of Critical Environmental Concern (ACEC). Eel Pond is not part of these protected areas.

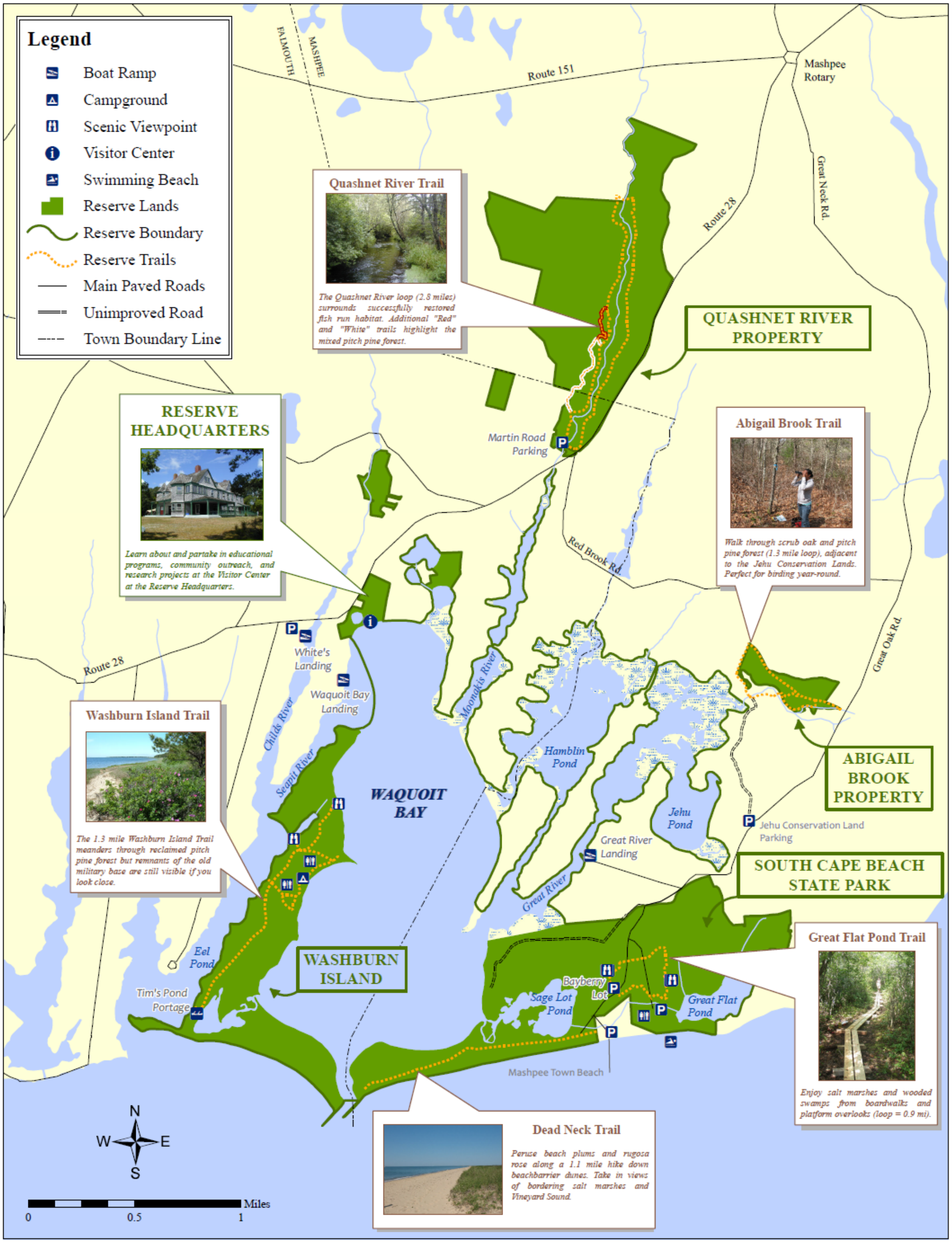


Figure 13: Waquoit Bay National Estuarine Research Reserve (WBNERR) and Area of Critical Environmental Concern (ACEC) Boundary

Section 3. Rotational Aquaculture License Sites (RALS)

Section 3A. Background

Falmouth's estuaries are a public resource where both families and commercial fishermen have harvested shellfish for centuries. Many other recreational activities such as boating and swimming are popular in these areas as well. As an overabundance of nitrogen has degraded water and sediment quality, shellfish populations have declined. As early as 1974, the Town's Shellfish Constable George Souza was experimenting with raising quahogs in West Falmouth's Quahog Pond for municipal propagation. His goal was to seed West Falmouth Harbor with quahogs and create more productive areas for wild quahog harvesting throughout the Town's "flats". News of his experiment, likely one of the first municipal propagation efforts on Cape Cod, was published in the November 11, 1975 edition of the Falmouth Enterprise. By 1998, the Town had installed an upweller on the Town dock in West Falmouth and was growing 1.5 million quahogs annually that were bottom-planted for commercial and recreational harvest. Today, the Town's municipal propagation program continues the mission of Mr. Souza to maintain and enhance the population of quahogs for public harvest. The Town has planted an average of 3.5 million quahogs that were started from seed annually over the past four years, not including the many bushels of quahogs relayed from one waterbody to another. There is also interest in developing viable methods for propagating other species such as scallops.

Propagating quahogs and other species and maintaining public access to the areas that have been harvested historically is an important goal of the Town. At the same time, private aquaculture provides an opportunity to promote local food production, foster local jobs and introduce larger quantities of shellfish into the town's impaired estuaries to rapidly improve water quality. To both improve the wild fishery as well as provide opportunities for aquaculture sites in appropriate locations, the Rotational Aquaculture License Site (RALS) model has been developed.

The economic, environmental and practical value of growing shellfish within several of the Town's estuaries is documented in Section 2A. While offshore aquaculture sites are not advantageous for the Town or growers, several historical offshore license sites already exist in Vineyard Sound and Buzzards Bay. As aquaculture planning and implementation moves forward, open water growers should be given right of first refusal on any expansions or new aquaculture license site proposals which are within 1000 feet of their existing aquaculture license site.

Concept Overview

The RALS model provides locations in certain estuaries for private aquaculture for commercial and recreational purposes, while at the same time enhancing these estuaries for wild harvesting through municipal propagation of quahogs and other species. The system works by establishing two to four distinct RALS sub-locations per grower. Only one sub-location is used per year, and the grower moves operations on either a two-year or a four-year rotation. During periods when an area is actively farmed using floating gear, nearby areas are concurrently bottom-planted with quahogs or other species that can be successfully planted and have commercial value such as scallops. Private aquaculture operations are then moved to the next sub-location to allow for wild harvesting of the bottom at the first sub-location. Areas that are municipally propagated are opened for wild harvesting depending on whether the species planted has reached a harvestable size and the

Town's health-related closure schedule. Moreover, all aquaculture activities in RALS within conditionally-approved estuaries are seasonal and are completely removed from all areas during periods when conditionally-approved areas are open for wild shellfish harvesting.

It is expected that DMF permitting for this approach in conditionally-approved areas is possible based on a recent program in Barnstable where aquaculture license-holders are potentially being permitted to grow in areas that are considered productive for commercial wild harvest and are also conditionally-approved. These aquaculture nursery areas are permitted on a seasonal basis, during the wild-harvest closure periods. Locating RALS in open estuaries will be done in a way that does not negatively impact commercial wild harvesters.

The RALS approach involves the following:

- The Town of Falmouth identifies and maps Aquaculture Development Areas (ADAs) and certain RALS within these ADAs
- DMF certifies these areas at the request of the Board of Selectmen (BOS)
- Town applies for permits from Army Corp of Engineers (ACOE) and Conservation Commission
- Individuals who are residents of the Town of Falmouth apply to the BOS for a RALS
    - Three types of license areas are available: Commercial Aquaculture, Introductory Trial Sites for commercial evaluations and Family Gardens
- Municipal propagation of quahogs and other commercially-important species such as scallops occurs in proximity to these areas concurrent with aquaculture operations
- License sites move annually or every two years (either a two or four-year rotation), and in conditionally-approved area only contain gear during periods when these areas are already closed to commercial and recreational wild harvest
- In open areas, the rotation of gear will be structured to allow for wild harvest of the bottom
- Specific terms and expectations for each RALS are a condition of the site license and the propagation permit

The first step in the implementation of ADAs and RALS is to define and site ADAs within appropriate areas of the Town's estuaries. Section 2 describes the process used to define the preliminary ADAs shown in Figures 1 through 12. In general, these areas were determined with the Shellfish Working Group (SWG) using a robust decision-making process. The SWG members represent a broad stakeholder group that includes commercial wild shellfish harvesters, aquaculture farmers, scientists and town staff Department of Marine and Environment and Town Manager's Office and appointed and elected official from the Conservation Commission, Coastal Ponds Committee and Water Quality Management Committee. A public hearing and subsequent meetings with commercial harvesters further refined the ADAs in several estuaries, including Great Pond, Bournes Pond and Waquoit/Eel Pond.

Section 3B. Types and Sizes of Rotational Aquaculture License Sites (RALS)

Within these ADAs, four classifications of RALS are envisioned, allowing for a range of aquaculture activities to occur, including:

- Full-Scale Commercial RALS
- Introductory Trial Sites for commercial evaluations

- Sites for Disabled Veterans
- Family/Recreational Gardening

The number of RALS sub-locations will vary, with more sites allocated to full-scale commercial operations and fewer sub-locations licensed for commercial trials and gardening. Based on the analysis presented in Section 2, sizes for each area could be as follows. This assumes a four-year rotation, and may be adjusted if a two-year rotation is implemented. Other adjustments may be made after discussions during the permitting process with authorities such as DMF and ACOE:

- Full-Scale Commercial RALS Area: maximum of 20,000 sq. ft.
    - In conditionally-approved estuaries:
        - Each grower receives permits for four RALS sub-locations within the conditionally-approved estuary (assuming a four-year rotation) but only one 20,000 sq. ft. site can be used per year (see Figure 14)
        - Each grower covers 20,000 sq. ft. annually
        - Each RALS sub-location of 20,000 sq. ft. will be for growing out seed in its first year only, up to an average size of 1.5 -inches and must be relayed to open areas for final grow-out to harvestable size
        - Each grower also receives permits for locations for final grow-out in open areas (as described below for open areas)
        - Timing and criteria for permit renewal and transfer will be defined during the implementation phase

    - In open estuaries:
        - Each grower receives permits for sixteen RALS sub-locations within an open estuary (assuming a four-year rotation) but only four of the 20,000 sq. ft. RALS sub-locations can be used per year (see Figure 14)
        - Each grower covers 2 acres annually
        - One RALS sub-location is used for first-year growth and the other three RALS sub-locations are used for second-year growth to marketable size.
        - Timing and criteria for permit renewal and transfer will be defined during the implementation phase

- Introductory Trial Sites for commercial evaluations: maximum of 20,000 sq. ft.
    - Each trial grower receives permits for four RALS sub-locations but only one 20,000 sq. ft. site can be used per year (see Figure 14)
    - Each grower covers 20,000 sq. ft. annually
    - This area includes both space for nursery and grow-out
    - These trial areas will change location on either a two or a four-year rotation
    - Timing and criteria for permit renewal and transfer will be defined during the implementation phase

- Sites for disabled veterans: maximum of 20,000 sq. ft.
    - Each disabled veteran receives permits for four RALS sub-locations but only one 20,000 sq. ft. site can be used per year (see Figure 14)

- Each grower covers 20,000 sq. ft. annually
- This area includes both space for nursery and grow-out
- These areas will change location on either a two or a four-year rotation
- Timing and criteria for permit renewal and transfer will be defined during the implementation phase

- Recreational/family garden area: number of oysters that can be grown by an individual will be based on wild harvest limits for oysters or other species grown over a season. This provision allows for recreational harvest of up to 13 bushels of oysters per year. At approximately 300 market-size oysters per bushel, the maximum annual harvest from a recreational or family garden area is no more than 3,900 oysters per year

- Smaller areas to accommodate mooring-based raft systems will be considered on a site-specific basis

To illustrate this concept based on a four-year rotation, Figure 14 shows how gear may be installed within an ADA. Other time intervals will be explored during the implementation phase.

Figure 14. Conceptual Representation of Four-Year Rotational Aquaculture License Site (RALS) Within ADAs. Left: Nursery/trial areas that are used for both Full Scale Commercial RALS as well as Introductory Trial Sites for commercial evaluations (20,000 sf on a four-year rotation). Right: Full Scale Commercial RALS areas (1.5-acre grow-out sites on a four-year rotation). Two-year rotations may also be evaluated.

RALS should be conditioned to reflect the terms and conditions of this approach and will be finalized during the implementation phase. Specific requirements could include:

- Renewal periods
- Gear requirements
- Minimum required biomass produced in Commercial RALS areas

For example, all RALS could be required to renew after one or two rotational cycles. Because they are located in the Town's coastal ponds, most of which are both conditionally approved and have potentially productive bottom for wild commercial harvesting, these license sites could have specific terms and conditions that are different from Town's standard aquaculture licenses.

Section 3C. Implementation

The general concept of a RALS is to enhance shellfish propagation for wild harvest while at the same time allowing certain areas within an estuary to be periodically used for private aquaculture in floating gear. A pilot phase is envisioned, where approximately two to four RALS are granted to individual growers and the program is monitored and evaluated. The exact number of RALS granted during the pilot phase will be determined prior to permitting. This pilot phase is intended to inform the program structure based on actual implementation. The knowledge gained through practical experience may lead to important modifications that will streamline and enhance the system of granting RALS and propagating quahogs and other species. Full-scale implementation will proceed based on the evaluation and recommendations of the pilot phase.

There are several benefits of the RALS approach:

- Maintains estuary bottom as a public resource for wild harvesting of shellfish
- Increases wild harvest of quahogs and other species by increased bottom-planting
- Allows private aquaculture in areas that have sufficient microalgae, and are warmer than open waters (Dame 2011, Gosling 2003, Lorio and Malone 1994). These are ideal growing conditions for shellfish, improving economic viability for new farms
- Allows private aquaculture in areas are that are protected and provide better working conditions for growers
- Maximizes the number of shellfish grown and harvested per unit area of aquaculture farm
- Promotes the cultural benefits of native species by making them more prevalent and thus available for people to experience
- Concentrates the filter-feeding benefits of shellfish into water bodies suffering from the worst nitrogen-impairment and eutrophication
- Accommodates riparian and littoral rights of upland landowners

This program works by having periods when areas that are bottom-planted with quahogs and other species are in proximity to areas that are actively farmed in floating gear, and periods where private aquaculture operations are moved to allow for wild harvesting of the species that were both planted and naturally available. During periods when aquaculture is occurring at a given location, wild harvesting would be prohibited, allowing the field-planted species to reach harvest size. Once the aquaculture operation rotates to a new location, the bottom-planted area would be opened to commercial and recreational harvest based on species size and the Town's health-related closure schedule. To illustrate the RALS approach, a four-year rotation of oyster aquaculture with quahog propagation is given. Other species may be proposed for both farming as well as propagation, and other rotation intervals may be explored.

As an example, the timing of a four-year rotation as shown in Figure 15 is as follows. The four RALS sub-locations that are rotated annually are designated in Figure 15 as RALS #1, RALS #2, RALS#3 and RALS #4. This system works as follows:

Year 1:

RALS Sublocation #1:

- Actively used for aquaculture and municipal propagation
- Closed to wild harvest

RALS #2, RALS #3 and RALS #4 are open to wild harvest of bottom during seasonal opening of estuary. These areas may also be left closed for a spawn season as part of ongoing municipal propagation planning.

Year 2:

RALS Sublocation #2:

- Actively used for aquaculture and municipal propagation
- Closed to wild harvest

RALS #1 area is actively harvested if appropriate size of propagated species is reached

RALS #3 and RALS #4 are open to wild harvest of bottom during seasonal opening of estuary. These areas may also be left closed for a spawn season as part of ongoing municipal propagation planning.

Year 3:

RALS Sublocation #3:

- Actively used for aquaculture and municipal propagation
- Closed to wild harvest

RALS #2 area is actively harvested if appropriate size of propagated species is reached

RALS #1 and RALS #4 are open to wild harvest of bottom during seasonal opening of estuary. These areas may also be left closed for a spawn season as part of ongoing municipal propagation planning.

Year 4:

RALS Sublocation #4:

- Actively used for aquaculture and municipal propagation
- Closed to wild harvest

RALS #3 area is actively harvested if appropriate size of propagated species is reached

RALS #1 and RALS #2 are open to wild harvest of bottom during seasonal opening of estuary. These areas may also be left closed for a spawn season as part of ongoing municipal propagation planning.

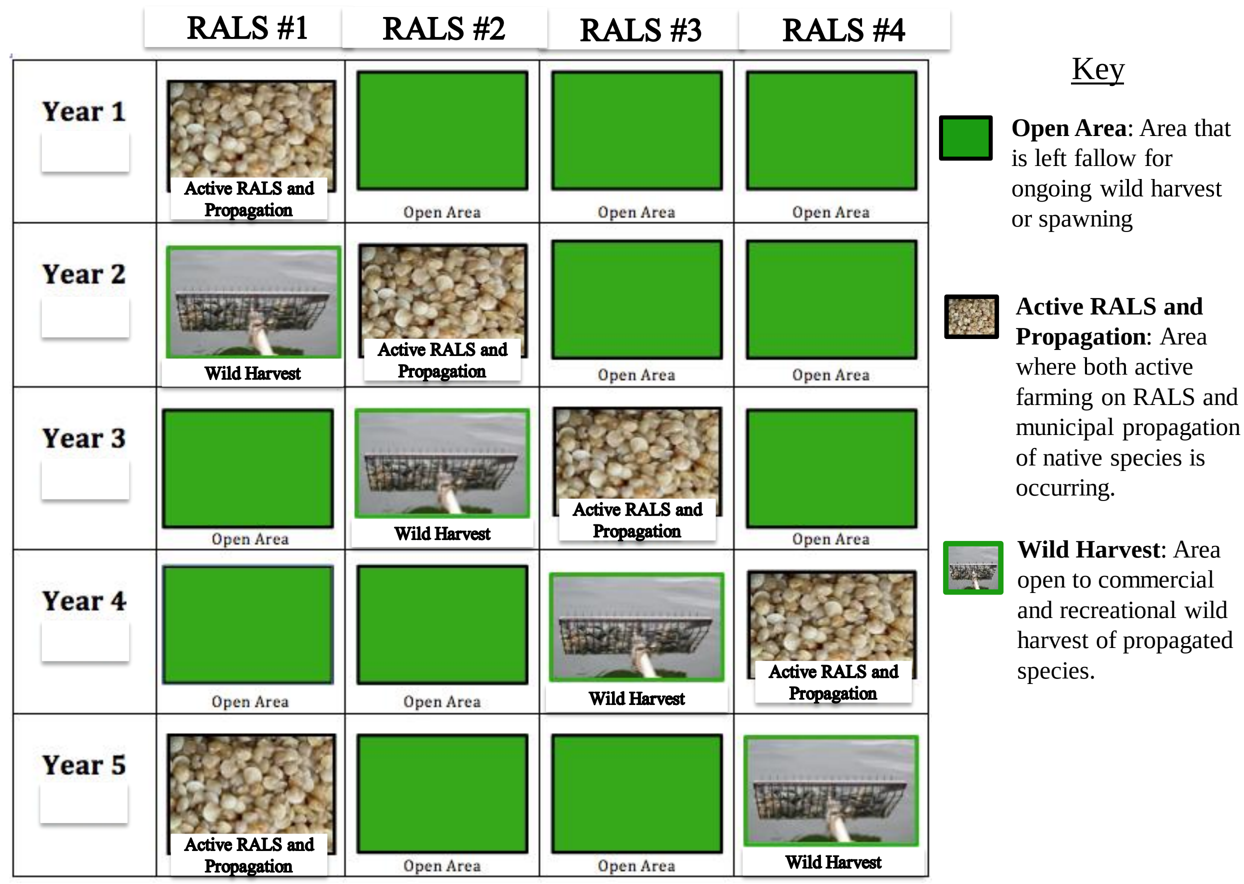
Year 5:

RALS Sublocation #1:

- Actively used for aquaculture and municipal propagation
- Closed to wild harvest

RALS #4 area is actively harvested if appropriate size of propagated species is reached

RALS #2 and RALS #3 are open to wild harvest of bottom during seasonal opening of estuary. These areas may also be left closed for a spawn season as part of ongoing municipal propagation planning.



Martinsen, 2016

Figure 15. Four-year private aquaculture and wild propagation schedule

As part of a grant provided by the Cape Cod Economic Development Council, the Coonamessett Farm Foundation prepared a white paper that outlines this concept with three rotational areas. Given the growth rate of hard clams and other species, four locations may be preferred. The approach of rotating over four sites annually also limits the period when bottom is not available for wild harvest to 25 percent of the time.

During the implementation phase, the timing of the rotations for the pilot phase will be defined.

Section 3D. Additional Space for Each RALS

The amount of biomass that can be grown at a given location is highly dependent on food availability, which includes both algae and particulates. Where the availability of food is not limited, a second factor that influences the biomass that can be grown is the type of gear used. The density of oysters that can be harvested per acre is also impacted by whether bottom planting is possible. If oysters that have already grown for one season (first-year oysters) can be grown to harvestable size on the bottom, stocking densities are much higher than if oysters need to be maintained in floating bags until they reach market size. The Cape Cod Commission Technology Matrix assumes 1 million oysters can be harvested per acre. This likely assumes bottom-planting. Published numbers in the Three Bays Shellfish Master Plan (2016) from Barnstable growers indicate that 400,000 first-year oysters can be grown through bottom-planting to harvestable size on one acre of hard bottom. Information from an off-Cape growing consortium indicates that between 500,000 and 1 million first-year oysters can be grown to harvest size on one acre of hard bottom.

In Falmouth, oysters are grown in gear for the first year at densities of up to 900 per bag. The configuration of this gear is shown in Figure 16 and scales to approximately 4300 bags per acre.

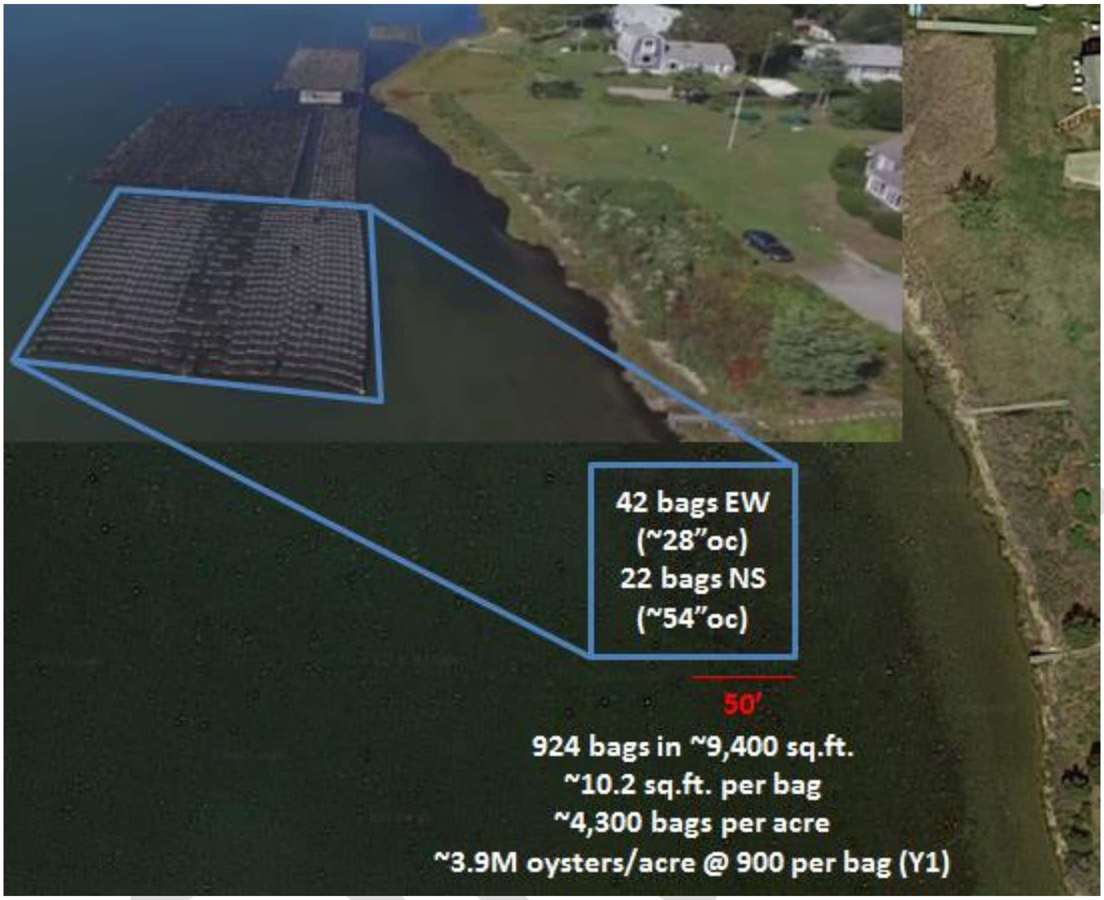


Figure 16. Floating Bag Densities Demonstrated by Municipal Oyster Propagation Operated by the Town of Falmouth in 2016.

Commercial densities may also vary from those planted solely for municipal propagation because growers must focus on producing an oyster with a size and shape that is optimally marketable. Cup shape is a key factor in the wholesale price offered for a crop of oysters. To grow an oyster that develops an appropriately deep cup, two approaches are used: low stocking density of oysters within gear, and tumbling to remove edges. For nutrient removal, shape is not as important as overall growth in total biomass. However, during the Lonnie's Pond Oyster Aquaculture Demonstration in Orleans, approximately 200,000 oysters were grown in 800 floating bags in an area of approximately 9,600 square feet. The end-of-season mass of oysters grown in this area was approximately 10 metric tons, with about half of the oysters at harvestable size. It should be noted that upon inspection by commercial growers and others, these oysters were found to be well-shaped with an acceptably deep cup.

The goals of growing premium grade oysters should be harmonized with the need to maximize oyster biomass density when finalizing gear configurations for the purposes of permitting RALS.

Another consideration when determining the size of RALS is that the ACOE Massachusetts General Permit for Aquaculture limits the amount of floating gear that can be installed on an aquaculture project site. The limits are the greater of 10% of the project area or 20,000 square feet. Thus, if a project is located on a site that is between 20,000 square feet and almost five acres, the total area covered by gear cannot exceed 20,000 sf.

Floating bags are:

- Widely used by growers on Cape Cod
- Able to be installed in high density configurations
- Lightweight, and therefore do not require significant strength to flip in order to control fouling throughout the growing season
- Lower cost for materials per bag than other systems
- Can be rapidly secured or moved in response to a forecast of severe weather
- Useable to grow other species in addition to oysters, such as quahogs to field-plantable size

Floating bags are recommended because they are cost effective and use space efficiently. Oysters grow well in floating bags. Moreover, operation and maintenance effort is low requiring flipping these bags weekly to control fouling. One person can flip the bags. 2017 costs for materials per bag are $13.30 including the long lines and augers. Larger sized floating systems have higher capital costs per unit, $32.78 for an OysterGro system and $42.89 for a LowProGro system. The materials costs for floating bags are less than half the cost of these other methods. Assuming it takes twenty minutes for assembly of a floating bag, even with an allowance for labor, they are the lowest cost gear option. And, the biomass of oysters that can be grown per unit area using floating bags is high. Because they work well in a variety of growing environments, the floating bag growing system is commonly used throughout Cape Cod. However, during the implementation and permitting phase, if it can be demonstrated that a different gear system is both low profile aesthetically and produces the same biomass of shellfish per unit area, it should be considered.

Figure 17 conceptualizes an installation of 400 floating bags in approximately 3800 square feet, which scales to 2100 bags per 20,000 square feet. This configuration is lower density than the format used in Falmouth and other Cape locations. This configuration works where the available food is high, and with the understanding that oysters growing in the center of the field are likely to grow more slowly than those along the edges. In Falmouth's estuaries, the floating bags can be installed in long, narrow strings, which allow for more uniform food availability.

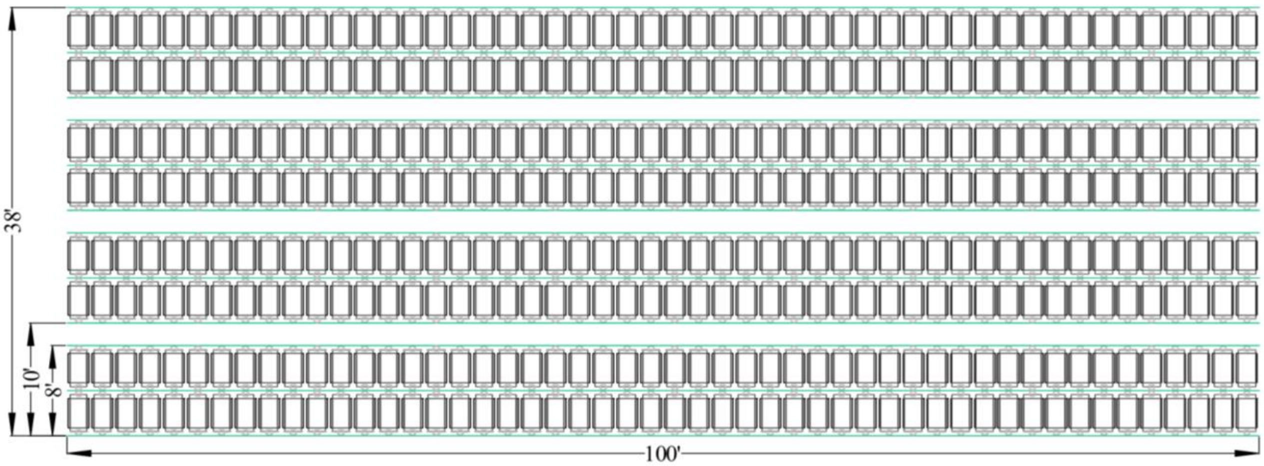


Figure 17. Example of a Floating Bag Layout that Scales 400 bags (above) to 2100 Floating Bags in just under half an acre (20,000 Square Feet)

Based on these demonstrated densities and the ACOE limits, RALS are sized at a half-acre to accommodate the maximum allowable coverage of floating gear.

Table 13 presents the number of RALS and area covered by floating gear for each estuary. The number of acres mapped for ADAs is derived from Figures 1 – 12. The half-acre RALS site for first-year seed is based on the demonstrated gear configuration in Figure 16 and Figure 17. For conditionally-approved estuaries, grow-out to harvestable size after the allowable nursery phase must be outside these waterbodies. For Megansett and Rands, the grow-out areas are located offshore in Buzzards Bay, outside Megansett Harbor. For Quissett, the grow-out area is in Outer Quissett Harbor, and for Great Pond, the grow-out areas could include either the preexisting licenses for offshore sites as well as other offshore sites. The final acreage for grow-out sites will be determined after the final number of nursery areas is determined.

There is a difference between the total acreage covered per grower within a conditional versus open estuary. This difference reflects the fact that grow-out during the second year occurs within the same estuary as the nursery stage. Growing oysters to marketable size requires approximately three times the number of floating bags and space, based on the lower stocking densities that are possible, and a ten percent mortality rate for the first year. Thus, for every half-acre nursery area that is fully utilized, 1.5-acres of grow-out area will be covered with floating bags.

The total acres covered with floating gear is calculated based on the coverage of 0.5 acres per RALS in conditional areas and 2 acres per license site for open areas to reflect the area needed for second year grow-out in the open estuaries.

Table 13 should be reviewed carefully with respect to the total area covered by floating gear.

Table 13: Preliminary Number of Full Scale Commercial RALS in Estuaries Included for ADAs

	Megansett	Rands	Quissett	Great	Bournes	Eel Pond	Waquoit
Number of acres mapped for ADA	4	NA	2	10	16	24	0
Number of 0.5 acre sites	8	NA	4	20	NA	NA	NA
Number of 2 acre sites	NA	NA	NA	NA	8	12	0
For conditionally-approved estuaries: Number of Rotational Licenses (RL) based on a 4-year rotation with grow-out at a different location (four sites per RL)	**2**	**1**	**1**	**5**	open	open	open
For open estuaries: Number of RL on a 4-year rotation with grow-out sites within estuary (four sites per RL)	conditional	conditional	conditional	conditional	**2**	**3**	**0**
Total acres covered each year if all Rotational Licenses granted	**1**	**TBD**	**0.5**	**2.5**	**4**	**6**	**0**
NOTE	0.5 acre covered per grower/YEAR	TBD	0.5 acre covered per grower/YEAR	0.5 acre covered per grower/YEAR	2 acres covered per grower/YEAR	2 acres covered per grower/YEAR	2 acres covered per grower/YEAR
Grow out site	Megansett Outer Harbor	Megansett Outer Harbor	Quissett Outer	Existing License Sites	Bournes	Eel Pond	Waquoit

Section 3E. Quantities of Oysters Grown

The number of oysters grown is different for the three types of RALS

The Full-Scale Commercial RALS are intended for full-scale commercial farming. If the number of floating bags and stocking density is maximized within a nursery area (2100 bags and 500 oysters per bag), approximately 1 million oysters can be grown from seed in the first growing season. With ten percent mortality, this creates approximately 900,000 oysters to be grown in the second year. Stocking densities of as low as 150 oysters per bag are used by growers selling into the premium, half-shell market where a deep cup and smaller ratios of length to width are important features. This quantity of oysters is presented as a maximum practical quantity for determining the area required for second-year operations.

Even for commercial farming, growing almost 1 million oysters is an ambitious undertaking, and requires capital for gear as well as sorting equipment. The labor involved is also significant. Therefore, any production requirements associated with these RALS could be reduced to 500,000 market-size oysters after the third or fourth year. This phasing allows for the sale of smaller quantities of oysters to help pay for the additional gear needed to ramp-up operations.

The commercial trial RALS are intended to allow new growers to experiment, so the production requirements are lower. For commercial trials, growers are expected to harvest 60,000 after the second season and 250,000 oysters by the end of the fourth season. If these production requirements are not met, these sites may be converted to full-scale commercial sites. A total of eight commercial trial sites are planned.

When discussing aquaculture with the general public, the idea of growing "one or two bags off my dock or mooring" is often suggested. Programs in some states allow "oyster gardening" to raise public awareness and inspire public participation. Because of health and safety concerns, this approach is only allowed in Approved waters of Massachusetts (Hickey et al. 2015). Furthermore, any shellfish grown must contribute to the public resource and cannot be grown for personal consumption. The third category of RALS provides a location for oyster gardening in Falmouth that allows for the gardeners to consume what they grow and is centralized and therefore able to be more easily managed by the Town. This area is located in the southesast section of Bournes Pond. Individuals would be allowed to grow the same quantity of oysters or quahogs that they would be allowed to take by wild harvesting. This ensures that these gardens are used for personal consumption only. The benefits of this concept in terms of public engagement and education are enormous.

Section 3F. Cost Sharing Goals

RALS are located within protected, highly advantageous growing areas that are also productive for wild shellfish harvesting. The Department of Marine and Environment requires additional staffing and budget to manage the implementation and oversight of the RALS program and purchase and grow the quahogs and other shellfish species that are a key aspect of this approach. Shellfish also uptake nitrogen, which may reduce the cost of infrastructure to meet regulatory water quality standards in Falmouth's impaired estuaries. In recognition of these facts, robust discussions on an appropriate cost share structure that apportions some percent of program costs to growers began during the development of this Aquaculture Plan. A full spectrum of options has been discussed, including:

- Surcharges to cover a portion of total program costs
    - Flat fee
    - Percentage of private sale
- In-kind contributions of seed for enhanced wild propagation
- Valuing the cost-reduction associated with nitrogen-uptake by shellfish

The overall principle is to apportion the costs of implementing the RALS program in a manner that incentivizes private growers to invest in large scale aquaculture and provides for reasonable cost recovery to secure benefits to both commercial wild harvesters and taxpayers.

There are several uncertainties related to the costs associated with this program and the avoided costs attributable to shellfish for nitrogen-uptake. It is unknown how many total RALS will be farmed, and the level of effort required to provide in-kind contributions of shellfish. In addition, grant funding is actively being pursued to defray the costs of permitting and pilot-scale implementation of this model program. For these reasons, decision making regarding cost-sharing will occur during the implementation phase of the program, with a maximum expected amount to be paid by growers established prior to the granting of any RALS. This timing is important so that growers can prepare business plans that accurately reflect this potential cost. Fees for commercial trial, disabled veteran, community garden plots and possibly other categories will also be established during the implementation phase.

Section 3G. Permitting

The first step in permitting RALS is to identify areas within the Town's coastal ponds where aquaculture operations would be appropriate. Section 2 presents preliminary recommendations for possible ADA locations. These locations have been reviewed through a robust public process that includes multiple meetings with various stakeholders. The next step is to review these locations through the local, state and federal permitting process.

Current Permitting Process for Individual Aquaculture Licenses

This current permitting process for aquaculture licenses in Falmouth is outlined in Chapter 275, Article III of the Town Code. Key considerations in this permitting process include:

- Applicant applies to Board of Selectmen (BOS) for approval of a "municipal aquaculture license site", referred to in Falmouth as an aquaculture license, and a public hearing is held
- Inshore sites are limited to an initial maximum of three acres, with two acres held in reserve for expansion after the initial five-year period of operation.
- Inshore site licensees may apply for additional acreage in up to five-acre increments after the initial five-year period
- Offshore sites are limited to ten acres for the first five years
- A fifty-foot buffer is required between adjacent sites
- If the license is approved by BOS, they request certification from DMF for this specific location
- Once DMF has certified the location, the applicant applies for an Army Corp of Engineers (ACOE) permit and Conservation Commission determination to place structures on the site
- Once all permits are in hand, DMF issues a propagation permit to the applicant, which gives the applicant permission to grow shellfish

Falmouth's current aquaculture regulations do not allow inshore licenses of more than three acres for the first five years of operations, increasing to an additional two acres after the first five-year period. Licensees may apply for additional acreage after the first five years of operation in up to five acre increments. To permit an aquaculture license in Falmouth, an applicant submits a specific location to the Board of Selectmen who will then hold a public hearing on the proposed spot. Input from the Shellfish Constable is an important consideration in this process. If the Selectmen approve the license, they then request a DMF certification of this site, which includes a biological assessment to determine whether the bottom is considered to be productive for wild species as well as a review of other environmental considerations. Aquaculture licenses cannot be permanently sited in areas with already productive bottom so as not to remove the area from the public resource.

After local approval of a license location and DMF certification, the license holder applies to the Conservation Commission and ACOE. As part of this permitting process, a Management Plan must be submitted. Then, a propagation permit can be issued by DMF. These permits allow the growing of shellfish in the state of Massachusetts. Propagation permits are associated with specific licensed areas and are only issued by DMF after certification and all other permitting. These propagation permits may also have conditions regarding species grown, gear type, minimum production standards, individuals allowed on the site and actions to take in the event of closures. These propagation permits are renewed annually.

Section 3G.1: Permitting and Licensing of Rotational Aquaculture License Sites (RALS) within Designated Aquaculture Development Areas (ADAs)

To streamline the permitting process for growers as well as maintain direct Town management and oversight over this rotational program, the environmental permitting of RALS within designated ADAs could proceed by having the Town initiate Conservation Commission and ACOE permitting after DMF certification of specific license sites. Licensing, as well as DMF certification and propagation permit issuance must be completed on a site-specific basis in connection with a specific individual named on the licenses and permits.

Prior to full scale implementation a pilot phase of implementation is envisioned, which involves the following steps:

- Address the programmatic considerations listed in Section 6 to formalize Town management responsibilities, license conditions and performance metrics for RALS
  - Conditions and other requirements could be added to individual licenses or could be codified in local regulations and referenced on licenses
- Locate specific RALS within one or two estuaries for a pilot-scale implementation project
- Identify applicants who will participate in the pilot project
- Issue licenses to selected individuals by BOS for the RALS identified for the pilot project
- Execution of a Memorandum of Agreement (MOA) with DMF delegating patrol responsibilities to Town
- Survey and certification of the license sites by DMF
  - This process may be expedited for seasonal areas if license is conditioned
- Permitting the gear type(s) allowed on these pilot RALS locations through Conservation Commission and ACOE

ACOE and Cons Com permits should be sought after DMF certifies the site because this certification will determine the threshold suitability of the area for aquaculture. In addition, the DMF Habitat Program is is only able to provide comments on the NOI and ACOE applications after the survey is completed. ACOE will likely not consider the applications complete until DMF issues its certification. Following pilot phase permitting and assessment of the pilot project, the Town will begin discussions with the DMF, MEPA and Army Corp of Engineers (ACOE) regarding the preferred approach for full scale implementation and may involve the following:

- Approve the general ADAs and the standards outlined in the plan by the Board of Selectmen
  - This is an internal Town vote and not part of the formal aquaculture permitting process outlined in MGL Chapter 130
- Locate specific RALS within these ADAs
- Identification of specific individuals who will hold the license for the RALS that have been located within these ADAs
- Vote by BOS for the issuance of licenses
- BOS request for site certification of approved licenses from DMF
  - DMF conducts expedited survey to issue its certification
  - Evaluate environmental thresholds that may be triggered
- Town submits application to the ACOE and NOI to Conservation to permit approved gear types on RALS
- Application for 10A permit by harbormaster to cover CH 91 requirements
- 10A, ACOE and Conservation Commission permits are granted to the Town

- Licensed growers then apply to DMF for a propagation permit. This propagation permit gives the applicant permission to grow shellfish within the licensed sites.

For DMF to certify these RALS and for the Town to apply to ACOE and Conservation Commission for permits, a management plan for ADAs and RALS that satisfies the requirement of MGL Chapter 130 sections 57, 59, 131, 91 and possibly MEPA is needed. It will at a minimum include mapped locations, performance metrics for growers to avoid impacts and maximize benefits, timing of licenses, gear types and configurations, and shellfish species. The Town may also establish production requirements. The management plan should also specify areas of municipal propagation within RALS estuaries.

The development of a management plan will streamline the permitting process because it meets the statutory requirements of MGL Chapter 130 for all sites. In addition, if the appropriate conditions are placed on the licenses (for example, licenses are seasonal and only operate during the period when an area is in the closed status) DMF can consider waiving the shellfish survey since this seasonal operation should not impact wild fisheries.

There are several ways for the conditions and other requirements of the management plan to be linked to the ADA and/or RALS licenses:

- A condition can be stated on the licenses for RALS and ADAs requiring that they must be operated in accordance with the management plan
- All of the conditions in the management plan could be repeated on each license
- A new category of aquaculture license for RALS and ADAs could be added to local regulations. These regulations would then enumerate the specific terms and conditions of the management plan, and would also be eferenced in the licenses issued by the BOS

The DMF-issued certification will also reiterate the specific terms and conditions from the management plan related to all RALS licenses. The DMF-issued propagation permit for individuals who have a license for a RALS within these ADAs may also include specific terms and conditions in the licenses related to maximum seed size, movement of seed, and other considerations. Once RALS are granted, they can be transferred by vote of the BOS in accordance with MGL CH 130 Section 58 and local regulations, new licensee will need to obtain a DMF propagation permit but will not need new permits from the Conservation Commission and ACOE.

There are several considerations with this approach:

- Permitting of all the ADAs in this Plan may trigger MEPA Review and require an Environmental Impact Report (EIR). A key issue that will be confirmed during the pilot implementation phase is the MEPA and other thresholds that are triggered. The segmentation regulations in CMR 301 will be considered as part of this evaluation.
- If the Town holds the ACOE permit and Conservation Commission Order of Conditions, the range of gear and other growing parameters need to be specified as part of the management plan
- If the Town holds the ACOE and Conservation site permits, all Conservation Commission and ACOE requirements and conditions are the Town's responsibility and liability
- DMF holds the applicant named on the site license and propagation permit responsible for all issues related to these permissions

This approach benefits commercial wild harvesters, growers and the Town as a whole. The RALS is structured to keep the areas currently used for commercial wild harvest open as they have been historically. Commercial harvesters will still have access to productive bottom during periods when these areas have been opened in the past. Commercial harvesters of wild shellfish also profit from this program because it increases the number of hard clams and other species planted as part of municipal propagation for commercial harvest.

For growers, this approach creates a framework that allows aquaculture operations to occur in estuaries that would typically be off-limits. The RALS framework may be the most practical way for DMF to permit aquaculture in conditionally-approved areas or areas that have productive bottom for commercial harvesting of wild species. This system also streamlines the permitting process for growers significantly, saving the time and expense associated with gaining state and federal approvals for aquaculture.

The Town benefits from this system in several ways. The nitrogen uptake and enhanced denitrification from shellfish is a benefit to in terms of avoided costs for infrastructure to remove this cause of eutrophication. At the same time, local jobs and food production is encouraged. In addition, this approach ensures local oversight at the site-management level. This level of local oversight is critical to ensuring that the specific aquaculture operations permitted in the Town's estuaries are operated in ways that are compatible with the multiple uses in these waterbodies. Fees for RALS can also be used to help fund the program, creating a budgetary pathway for enhanced municipal propagation. This program is truly a win-win-win.

If the Town simply designates potential ADAs but does not permit them, the current permitting process is not shortened for the grower and the Town does not maintain management oversight of gear and growing configurations.

Section 3H. Gear Specifications

For permitting of structures within ADAs, both the ACOE and Conservation Commission require gear specifications. Key consideration related to permitting of gear requires that the following be specified:

- Type of sediment in the area where gear will be placed
- Types of underwater structures including anchoring systems that hold gear in place
- Types of floating structures
- Plans that minimized the amount of bottom gear
- A workable Storm Management Plan

The following gear specifications are recommended, as described in detail in Section 3D

- Floating bags (ADPI bags of between 4 mm – 9 mm, floats, clips)
- Longline or other line that creates a tight string along which bags can be attached
- Helical augers to anchor lines in place
- Site specific anchoring system for certain estuaries such as Megansett based on a field survey of bottom types
- Orientation of gear will be determined on a site-specific basis, based on prevailing wind or tide
- Requirement for tight, orderly arrangement of gear within a RALS footprint

Oysters, quahogs, scallops and other species may be grown, as long as the total number of animals is appropriate to the nitrogen-removal objectives of the program. Other gear may be proposed as long as it allows for comparable overall shellfish densities and is aesthetically in keeping with the floating bag paradigm in terms of profile and neatness.

Section 4: Quantities of shellfish needed to meet water quality goals and overall potential for nitrogen-removal of the Rotational Aquaculture Plan

Table 14 estimates the number of shellfish that can be grown and the kilograms of nitrogen removed using the rotational model described in Section 3 and shown in Table 13. The areas available for oyster aquaculture and municipal quahog propagation are based on the preliminary areas that have been identified for aquaculture in this plan. Oyster biomass is the critical indicator of nitrogen uptake. For these planning-level calculations, the oyster biomass and nitrogen uptake of the first-year nursery areas is assumed to be equivalent to 315,000 market-size oysters. This number of market-size oysters is calculated for an installation of 2100 floating bags in a 20,000 sf area and a final stocking density of 150 oysters per bag. The nitrogen-content of a 3-inch oyster grown off-bottom or cherrystone quahog is based on published values from Woods Hole Sea Grant (Reitsma et al. 2016). For enhanced denitrification, some studies have shown that the nitrogen removed by the increase in denitrification caused by oysters is equal to the mass of nitrogen contained in the oyster (Newell et al. 2005; Kellogg et al 2013). Recent work in Lonnie's Pond, Orleans MA has demonstrated enhanced denitrification caused by oysters is 67% of uptake. SMAST will be studying denitrification in Bournes Pond during the 2017 growing season. The number of quahogs planted is based on a stocking density of 25 per square foot, with broadcasting for final grow-out.

Based on planning-level estimates, the total number of shellfish being grown at full-scale implementation:

- 9.5 million first-year oysters
- 5.7 million oysters to marketable size
- 9.5 million quahogs

The wholesale value of a market-size oyster is approximately $0.35 and a littleneck quahog is $0.20. Depending on survival, the economic benefits of this program could be significant.

Table 14: Preliminary Nitrogen Removal Calculations for Estuaries Included for ADAs

	Megansett	Rands	Quissett	Great	Bournes	Eel Pond	Waquoit
Number of acres mapped for ADA	4	NA	2	10	16	24	0
Number of 0.5 acre/20,000 sq. ft. Rotational Aquaculture License Sites (RALS)	8	NA	4	20	32	48	0
For conditionally-approved estuaries: Number of Rotational Licenses (RL) based on a 4-year rotation with grow-out at a different location (four RALS per RL)	**2**	**1**	**1**	**5**	open	open	open
For open estuaries: Number of RLs on a <u>2-year</u> rotation with grow-out sites within estuary (four RALS per RL)	conditional	conditional	conditional	conditional	**4**	**6**	**0**
Total acres covered each year if all Rotational Licenses granted	**1**	**TBD**	**0.5**	**2.5**	**8**	**12**	**0**
Total number of first year OYSTERS grown anually per RALS at 500,000/year	1,000,000	500,000	500,000	2,500,000	2,000,000	3,000,000	-
Total Number of second year OYSTERS grown annually per RALS at 315,000/year					1,890,000	1,890,000	1,890,000
Total number of QUAHOGS grown anually per RL at a propagation of 500,000 quahogs per RALS	1,000,000	500,000	500,000	2,500,000	2,000,000	3,000,000	-
Kilograms of nitrogen-removal at .14 grams per oyster or quahogs per year	280	140	140	700	825	1,105	265
Kilograms of nitrogen-removal with enhanced denitrification at 50% of uptake	**420**	**210**	**210**	**1,050**	**1,237**	**1,657**	**397**

Section 5: Other Issues

Section 5A: Infrastructure Needs and Mooring Consolidation

Key infrastructure needs may include:

- Reconfiguring existing mooring fields to enable space for RALS and increase viable habitat for eelgrass
- Access points to water, including areas to launch a skiff
- Upweller space for growing small (approximately 2-3 mm) seed to a size that can be installed in floating gear
- Storage space for gear
- Overwintering options

Consolidating existing mooring areas has several benefits. It would provide areas within estuaries for RALS in locations where the bottom is likely not currently harvested. It would also reduce the amount of disturbed bottom, which may enable eelgrass to regrow.

Additional upweller locations have also been identified in this plan, including publicly-owned parcels around Wild Harbor. The town could provide options for growers to lease space within tested established overwintering areas and a municipal climate-controlled overwintering facility. These issues could be addressed as part of the implementation phase of this plan.

Section 5B. Role of Municipal Propagation

The Town of Falmouth municipal propagation program approximately 2.5 million oysters and up to 2.5 million quahogs annually. A key feature of the RALS approach is municipal propagation of quahogs and other species as part of the aquaculture siting. This enhances the wild resource while promoting additional aquaculture operations. Municipal propagation will continue in the role of enhancing the wild fishery that was begun decades ago.

In addition, the Town's municipal propagation program can begin to support private and recreational aquaculture by providing:

- Upweller space
- Overwintering options
- Larger seed

Municipal propagation can play an important role in alleviating some of the constraints on the productivity of private aquaculture by providing upweller space for private growers to start small seed. In addition, providing a location that has been proven to be successful for overwintering first-year oysters that have reached approximately 2-inches may also benefit local growers. This will allow seed that is grown in nursery areas to be held in a safe location for second-year grow-out.

There is also a desire to explore the value, appropriateness and permitting of having the town provide intermediate-size shellfish to local growers. This intermediate seed only require a month or two to reach harvest size for commercial sale. To illustrate the value to the grower of intermediate seed, it is assumed that a grower purchases intermediate seed for $0.20 each, and these oysters are sold for $0.40 each two months later, during the peak season of August and September. At these prices, a grower using 500 bags with 200 oysters each would have a net revenue after paying for the seed of $20,000. The expenses beyond the seed would be minimal and would include a few weeks of work on the water in the summer. There are also questions relating to the impacts to the private sector of municipal sale of intermediate seed. As part of the ongoing work of the Department of Marine and Environmental Services, issues relating to the sale of intermediate seed will continue to be discussed with DMF and others.

There are a number of steps to be accomplished as this plan moves to the permitting and implementation phase that are listed in Section 6, Next Steps. To implement the Rotational Aquaculture Plan, additional staffing for municipal propagation of quahogs and other species, ADA permitting, management and oversight and patrolling will likely be needed.

Section 5C. Economic benefits of local fisheries and aquaculture

Another noteworthy aspect of both commercial shellfishing as well as aquaculture is that they create economic activity in terms of labor wages that enhance the local economy. This benefit to the local economy should not be overlooked in weighing alternative approaches for nitrogen-removal within the Town's estuaries. Using shellfish to remove nitrogen is both advantageous economically and environmentally.

The economic multiplier for local shellfisheries and aquaculture has been estimated at between $1.79 to $1.90 for every dollar in wages created (Augusto, Holmes and Barnes 2015, Northern Economics 2014). A multiplier for commercial wild shellfish harvest has been valued at 4.5 (Massachusetts Division of Marine Fisheries 2003). Commercial wild harvesting and shellfish farming create revenue. Much of this revenue will likely be spent on wages and salaries. Based on these multipliers, the increased economic activity generated in the local economy is significant.

CCCE/Woods Hole Sea Grant/SEMAC contracted with the UMASS Center for Marketing Research to conduct an economic survey of the aquaculture industry in Massachusetts. Sample of results include:

- The output of the shellfish aquaculture industry in Massachusetts was valued at approximately $25.4 million in 2013, which in turn generated approximately $45.5 million in the Massachusetts economy, or 1.79 times the activity
- Shellfish farmers were responsible for approximately 909 jobs
- Shellfish farmers paid approximately $11.9 million in wages in 2013. Their economic activity generated additional labor income of $8.2 million, for a total of approximately $20.1 million in labor income in MA

The Rhode Island Shellfish Management Plan points out that global aquaculture production is growing, and approximately 50 percent of seafood consumed globally is cultured. The U.S. aquaculture industry produces $1 billion in seafood, but this is less than 5 percent of the seafood consumed in the U.S. Studies have shown that, done properly, shellfish aquaculture is a sustainable method of food production that also provides important ecosystem services, such as providing critical habitat for juvenile fish and also removing nitrogen from the water.

Local food production is a cornerstone of long-term sustainability because of the reduced energy costs required to ship this food. Moreover, local shellfish production does not use fertilizer, pesticides or feed, making shellfish a uniquely positive crop to farm from an environmental perspective. Shellfish are one of the most practical and valuable crops to grow on Cape Cod. Shellfish aquaculture is a type of local business worth promoting in

Falmouth. There are currently 50 commercial shellfish licenses granted in Falmouth, with a moratorium on any additional commercial licenses because the local wild fishery cannot support more. The enhanced municipal propagation that is envisioned as part of implementing this plan may help alleviate the current resource constraints and allow for more commercial shellfish licenses to be supported.

Section 6. Programmatic Considerations/Next Steps

The draft Falmouth Rotational Aquaculture Plan was presented and reviewed with a wide range of stakeholders through Shellfish Working Group meetings, discussions with the Division of Marine Fisheries, at two Public Hearings and at a Board of Selectmen's meeting. This draft plan reflects comments and suggestions from these sessions. The implementation phase of this program should include these elements:

- Permitting of the overall ADA areas through the Conservation Commission and Army Corp of Engineers (MGL CH 131 and 91)
- Mapping specific areas for several RALS locations for a pilot phase of the program
- Permitting of specific RALS in both open as well as conditionally approved estuaries through the Division of Marine Fisheries
- Development of a MOA between DMF and the Town to establish town patrol requirements for conditionally approved areas
- Finalizing the mechanics of the rotational program at a pilot scale, including:
    - Type and quantity of species to be grown in RALS
    - Final gear specifications
    - Type and quantity of species to be propagated for commercial and recreational harvest
    - Number of years for rotation at each site
    - Transplant locations for second year grow-out in conditionally-approved areas
    - Require gear-removal in conditionally-approved areas
    - Review need for gear-removal in open areas
    - Process and criteria for selecting growers to farm these pilot sites
    - Timing and process for renewing these sites
    - Transfer requirements of these sites (is local residency required for transfer)
    - Municipal management including patrol schedule
- Addressing mooring consolidation if needed to increase RALS sites
- Creating an equitable system for distributing the RALS if demand is greater than the number of sites available at full-scale implementation
- Estimating the costs to growers of starting an aquaculture business on a RALS
- Addressing the cost sharing goals of this program, including an evaluation of the potential avoided costs of infrastructure due to nutrient uptake of shellfish and the availability of nitrogen-trading credits and the state or federal level that can be used. This requires:
    - Calculating the costs of this program
    - Determining the number/species of shellfish that can be grown through this program
    - Defining a way of calculating the avoided infrastructure costs of the nitrogen-removal
    - Researching the availability and mechanics of nitrogen trading that may apply
- Meeting the short-term and long-term staffing and other budgetary needs of the MES department to execute and manage this program

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Appendix A: Fact Sheet

Fact Sheet

Falmouth Rotational Aquaculture Plan, May 2017

Falmouth is a special place. Over the past 50 years, development has compromised estuarine water quality and led to significant loss of invaluable marine habitat. Our salt ponds, estuaries and harbors are the critical nurseries and rookeries for shellfish and finfish as well as birds and mammals that form the basis of a complex food web. Within our lifetime, we can start to return Falmouth's estuaries to the vibrant ecosystems they once were. Shellfish propagation is a key component of this restoration effort.

Shellfish aquaculture operates within a public resource which has multiple user groups. The overarching goal of the Falmouth Rotational Aquaculture Plan is to meet the needs of all these groups - growers, wild harvesters, neighbors, visitors, mooring holders, and taxpayers. The next steps in the planning process include:

- Presenting this plan to stakeholders, neighborhood groups and the general public; and
- Addressing implementation issues such as overwintering of shellfish and covering the costs of running this program in a way that is fair and equitable.

Below is an executive summary of the regulatory context and the objectives of the Falmouth Rotational Aquaculture Plan which are further detailed in the 80+ report (available online at http://www.falmouthmass.us/862/Falmouth-Rotational-Aquaculture-Plan

- The town is trying to expand aquaculture AND increase municipal propagation for wild harvest AND address aesthetic concerns of neighbors AND meet regulatory requirements AND remove nitrogen in a quantifiable way for TMDL-compliance AND address the costs of implementing this plan.

- Expanding private aquaculture into estuaries using the rotational system makes sense for everybody. Growers benefit by having ideal growing locations; the local economy benefits from creation of new businesses and jobs; local restaurants benefit from the increased supply of local shellfish; commercial harvesters benefit by an enhanced wild resource; taxpayers benefit by a reduced cost of infrastructure to remove nitrogen from the water; and all residents, taxpayers and businesses benefit from the removal of microalgae to help clean up these impaired waterbodies. We believe these benefits can be attained without an undue burden to neighbors and other users of the waterways because placement of aquaculture areas has been carefully planned and moves annually so that no one area on the water is permanently affected.

- Without a rotational system, private aquaculture would only be allowed to expand in much less desirable offshore locations because:

- Nine of fifteen estuaries in Falmouth are conditionally approved for shellfishing, and have historically enjoyed productive bottom for wild harvesting -- traditional, private aquaculture is prohibited in these locations. The rotational system we are proposing addresses this issue from a regulatory perspective and thus opens these areas for private aquaculture; and

- Of Falmouth's fifteen estuaries, two are open for shellfishing and have historically had productive bottom. Private aquaculture cannot be located in areas with productive bottom. There are possibly one or two small sections of these estuaries are not productive areas, significantly limiting the potential for private aquaculture here. The rotational system accomplishes the goal of allowing private aquaculture to expand into these two open estuaries in Falmouth.

- The rotational system requires an operations manager to serve as a liaison with neighbors, to ensure transitions are managed and permit conditions are enforced. Someone from the Town needs to be both in the field and available to assist administratively for this level of commercial activity within our coastal ponds. This manager will also need to ensure the biomass of shellfish for nitrogen-removal is quantified and the quahogs are planted, maintained and harvested at appropriate times. This is a full-time job that is a direct result of expanding aquaculture in town.

The Falmouth Rotational Aquaculture Plan seeks to benefit all users of the town's estuaries, both economically and environmentally and balance the harvest goals of commercial, recreational, senior, and family diggers with aquaculture growers and town water quality goals.

For more information, please contact Sia Karplus, Science Wares, Inc. at sia@sciencewares.com

Appendix B: Segmentation Section of 301 CMR 11

11.01: continued

(c) Segmentation In determining whether a Project is subject to MEPA jurisdiction or meets or exceeds any review thresholds, and during MEPA review, the Proponent, any Participating Agency, and the Secretary shall consider the entirety of the Project, including any likely future Expansion, and not separate phases or segments thereof. The Proponent may not phase or segment a Project to evade, defer or curtail MEPA review. The Proponent, any Participating Agency, and the Secretary shall consider all circumstances as to whether various work or activities constitute one Project, including but not limited to: whether the work or activities, taken together, comprise a common plan or independent undertakings, regardless of whether there is more than one Proponent; any time interval between the work or activities; and whether the environmental impacts caused by the work or activities are separable or cumulative. Examples of work or activities that constitute one Project include work or activities that:

一. meet or exceed one or more review thresholds on an area previously subject to a Land Transfer, provided that not more than five years have elapsed between the Land Transfer and the work or activities; and

一. construct more than one structure (such as more than one single family dwelling) and appurtenant structures, facilities, and other improvements on a site, unless a plan for the subdivision or other legal division creating or allowing separate lots or parcels was definitively approved or endorsed in accordance with applicable statutes and regulations prior to the effective date of 301 CMR 11.00.